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Electric vehicle penetration, Comparison between Norway, Japan and Spain.

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Abstract:

A study has been carried out regarding the penetration of the electric vehicle and the infrastructure that this entails in order to find possible new factors, tax incentives, subsidies and related aids, which increase the effectiveness of the penetration of the electric vehicle in Spain through comparison with the methodology of Norway and Japan in front of it.

The main results to be highlighted fall into the difference of strategies in relation to the tax incentives, subsidies and relative aids of each one of the countries is carrying out and the results of these. Thus, Norway is the country that most reduces the price of electric vehicles in percentages without offering subsidies, but with the tax collection strategy that applies, only tax incentives are necessary to achieve a reduction in the purchase price of the Electric vehicle less than the gasoline vehicle. Japan, on the other hand, the strategy of tax collection through the purchase of a vehicle is much lower than in Norway, which means that complementary subsidies are needed. However, Japan cannot reduce the price of electric vehicles below gasoline. Despite this, Japanese population is greatly encouraged by concerns about the environment, and a surprising factor is that the Japanese population greatly appreciates the possible use of electric car battery in the event of a catastrophe as a major earthquake. Spain, on the other hand, uses a mixed strategy between Japan and Norway, this strategy of tax collection allows it to reduce the price of the electric vehicle using fiscal incentives considerably, but it is not sufficient and needs to complement it with subsidies. Spain achieves a certain balance between the price of the electric vehicle and the gasoline but remains at seventeen percent above the price of the gasoline vehicle.

In terms of infrastructure, we do not consider the amount of investments between them to be comparable, given that the characteristics of the country with very different ones, but we should mention the relationship between the results obtained by Norway with the least investment in the three countries. This is due to the prohibition of sales, production and new registrations of gasoline / diesel vehicles from 2025, this fact has led to companies in the private sector of petroleum or gasoline / diesel vehicles to invest in freight stations electric Another factor to note is that Norway is the only country of the studied ones that has an official database (NOBIL) that provides real-time information on the country's electrical charge infrastructure, location and technical characteristics.

When it comes to future aspects to improve in the case of Spain, an increase in the generation of electricity from renewable energies compared to current 35% and 98% achieved by Norway is necessary to achieve a sustainable mobility through electric vehicle. The increase of information transmitted to the population on the charging infrastructure and the subsidies that the Spanish government offers to promote the electric vehicle is very important and need to be increased. The revaluation of the increase in the amount invested in the depletion of resources 24 hours after the publication of these for several consecutive years. Finally, proposals to solve the problem of the population segment that does not have an indoor parking lot nor have access or alternative chargers are necessary to guarantee a complete restoration of the electric vehicle.

Resum:

S'ha realitzat un estudi en quant a la penetració del vehicle elèctric i de la infraestructura que aquest comporta amb l'objectiu de trobar possibles nous factors, incentius fiscals, subsidis i ajudes relatives, que augmentin l'efectivitat de la penetració del vehicle elèctric a Espanya a través de la comparació amb la metodologia de Noruega i Japó davant d'aquesta.

Els principals resultats a destacar recauen en la diferencia d'estratègies en quan als incentius fiscals , subsidis i ajudes relatives que cada un dels països esta duent a terme i els resultats d'aquests. Així, Noruega és el país que més redueix el preu del vehicle elèctric en percentatges sense oferir subsidis, sinó que amb l'estratègia de recaptació d'impostos que aplica només li és necessari incentius de tipus fiscals per assolir una reducció de preu de compra del vehicle elèctric inferior al del vehicle de gasolina. Japó, en canvi, contràriament , l'estratègia de recaptació d'impostos a través de la compra d'un vehicle és molt inferior a Noruega, aquest fet té com a conseqüència que es necessitin subsidis complementaris. Tot i això, Japó no aconsegueix reduir el preu del vehicle elèctric per sota del de gasolina. Malgrat això, la població japonesa es veu molt incentivada per la preocupació pel medi ambient , a més, un factor sorprenent és que la població japonesa aprecia molt el possible ús de la bateria del cotxe elèctric en cas d'una catàstrofe com una gran terratrèmol. Espanya, per altra banda, utilitza una estratègia mixta entre la de Japó i Noruega, aquesta estratègia de recaptació d'impostos li permet reduir el preu del vehicle elèctric utilitzant incentius fiscals considerablement, però no son suficients i necessita complementar-ho amb subsidis. Espanya aconsegueix un cert equilibri entre el preu del vehicle elèctric i el de gasolina però es queda a un disset per cent per sobre del preu del vehicle de gasolina.

En quant a la infraestructura, no considerem comparables la quantitat de les inversions entre elles ja que les característiques del país con molt diferents, però, cal esmentar la relació entre els fruits que ha obtingut noruega a través de la menor inversió dels tres països. Aquest fet és degut a la prohibició de les ventes, producció i nous registres dels vehicles de gasolina/dièsel a partir del 2025 , aquest fet ha portat a empreses del sector privat del petroli o dels vehicles de gasolina/dièsel a invertir en estacions de càrrega elèctriques. Un altre factor a destacar és que Noruega és l'únic país dels estudiats que té una base de dades oficial (NOBIL) que proporciona informació a temps real sobre la infraestructura de càrrega elèctrica del país, localització y característiques tècniques.

En quan a futurs aspectes que millorar en el cas d'Espanya, un augment de la generació d'electricitat a partir d'energies renovables davant del 35% actual i el 98% assolit per Noruega és necessari. L'augment d'informació transmesa a la població sobre la infraestructura de càrrega i els subsidis que el govern Espanyol ofereix per promoure el vehicle elèctric és necessari. El replantejament de l'augment de la quantitat invertida davant de l'exhauriment de recursos 24h després de la publicació d'aquests durant varis anys consecutius. Finalment, propostes de solució al problema del segment de població que no disposa d'un pàrquing interior ni tenen accés o carregadors alternatius són necessàries per garantir una total instauració del vehicle elèctric.

1.Introduction and scope

The present academic study is dedicated to the process of electric vehicle penetration in Norway, Japan and Spain. Norway because it is the country with the largest market share in the world and a shining example for the rest of the countries also in the generation of electricity from renewable energies, Japan, because it is a country with a very high population density and the which is one with the highest density of fast charging stations due to the public-private treatment that the Japanese government has achieved with the association CHAdeMO and Spain, a country that does not stand out for its development in the electric vehicle market and has much learn about Norway and Japan.

To analyse this problem, it is necessary to mention its causes. The main cause of the idea of establishing the electric vehicle as a mode of mobility is that Greenhouse gases (GHG) is the main responsibility of the "human illness" the world is suffering, and Transportation Sector has big guilty in it. Transport Sector currently accounts for 23% of global energy-related GHG emissions and about 73% of these GHG comes from road transportation, thereupon, reducing emissions of Transport Sector would be very effective to reduce global GHG. To achieve this objective an electrical vehicle establishment is imperative.

To analyse this problem, we have addressed an initial first part where the environmental impacts of maintaining the policies and growth rate of the demand for current vehicles in OECD and non-OECD will be discussed. We will see that the growth of the demand of the different modes of transport changes according to the group of countries and we will analyse in which countries we should act to minimize the impacts of the generation of CO_2 and air-pollutants represented by vehicles as of today and future scenarios of demand growth and emissions. We will also analyse the oil consumption that is carried out globally and what percentage represents the transport sector in that aspect. Then the controversy of whether generating more electricity can induce an increase in oil consumption will be analysed and we will compare the global percentage of renewable energies with fossil fuels.

Secondly, we will expose basic technical knowledge for the understanding of the study, we will see the types of traditional and electric vehicles depending on the engine they use for the traction, the types and powers of electric chargers that are used in Europe and Japan with the different connectors and charging times they offer.

In the third place, the evolution of the market share, the evolution of the fast and normal charging stations and the type of incentives that these countries are using to encourage the change of the vehicle from gasoline to the electric vehicle will be analysed in each of the countries. both plug-in hybrid vehicle (PHEV) and battery electric vehicle (EV). We will analyse in each country how the government is supporting the creation of new charging points and how much investment each country is dedicating to achieve it. We will also see how each of the governments makes known and transmits information to the population through databases in terms of the new charging points that are being built and the information of the current charging points, location, availability and charging characteristics.

In addition, we will make a current comparison of the price of an electric vehicle considering the reductions of the purchase price either by fiscal incentives, by subsidies or by a combination of both and we will see which countries achieve a greater price reduction and balance the price with the gasoline vehicle and which are still far away. We will explain carefully each of these incentives and the percentage of price reduction that they mean depending on the price of the vehicle. We will also direct the price comparison adding the costs of use in a period of ten years or once driven 200,000km, we will see that the percentages of fuel costs and other costs change and the balance of prices is balanced in some cases.

Finally, we will contrast the results we have obtained with market studies and surveys of each of the countries to see what the population thinks in each of the cases, what are the most appreciated advantages, the disadvantages that most concern and as is believed that the penetration of the new electric vehicle technology could be improved.

2. The important needing of E.V

Electric vehicles hold the potential to transform the way the world moves. EVs can increase energy security by diversifying the fuel mix or totally electrical vehicles and decreasing dependence on petroleum, while also reducing emissions of GHG and other pollutants, nowadays the global percentage of transportation GHG emissions is 23%. Just as important, EVs can unlock innovation and create new advanced industries that spur job growth and improve economic prosperity. However, the mass deployment of EVs will require transportation systems capable of integrating and fostering this new technology. To accelerate this transition, cities and metropolitan regions around the world are creating EV-friendly ecosystems and building the foundation for widespread adoption. Associations as the Electric Vehicles Initiative (EVI), a multi-government policy forum established in 2009 under the Cleaning Ministerial (CEM), are dedicated to accelerating the deployment of EVs worldwide.

Furthermore, EV can decrease the city noise due to the silence electric engine, however, this difference is appreciated under 30 km/h because with higher velocities road noise can be neglected by the road noise (Lykke, 2012). However, in large cities most common velocities are under 30 km/h and can be very effective.

2.1 Global advantages

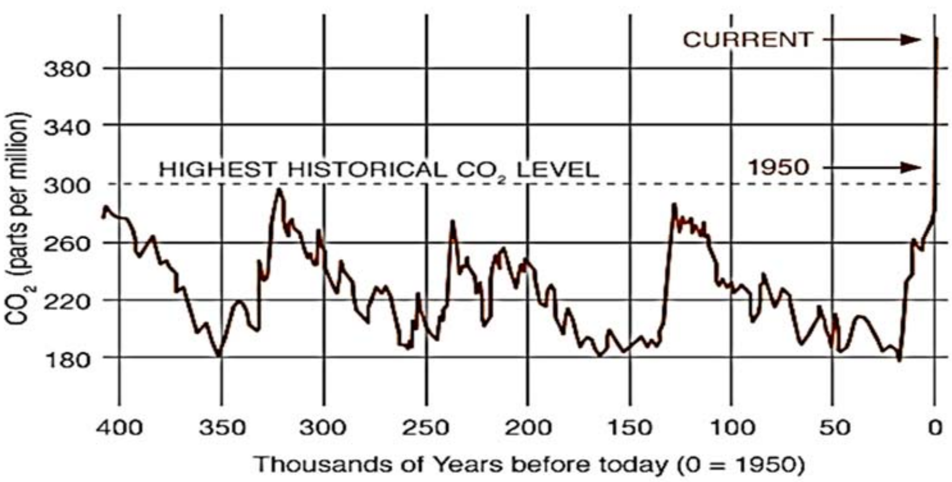
2.1.1 Reducing GHG and Air Pollutants

2.1.1.1 Brief introduction of the world "illness".

Having a look back into world history, based on National Oceanic and Atmospheric Administration data (NASA), the ancient air bubbles trapped in ice enable us to step back in time and see what Earth's atmosphere, and climate, were like in the distant past. That show us that level of CO_2 in the atmosphere nowadays is higher than ever in the last 400.000 years. During ice ages, CO_2 levels were around 200ppm (parts per million) and in the interglacial periods around 280ppm. As we can see in the Graphic 1 today the levels of CO_2 reach 400ppm for the first time in the earth history.

This recent increase in CO_2 let us confirm about the constant relationship with the fossil-fuel burning. According to NASA data, the 60% of fossil-fuel emissions stay in the air, so, if fossil-fuel burning continues and humanity don't invest in finding a peak for the CO_2 values, these will continue to rise to levels of 1500ppm and the atmosphere would then not return to pre-industrial levels even in thousands of years.

Graphic 1. Carbon dioxide level (parts per million) evolution since 400k years before 1950.



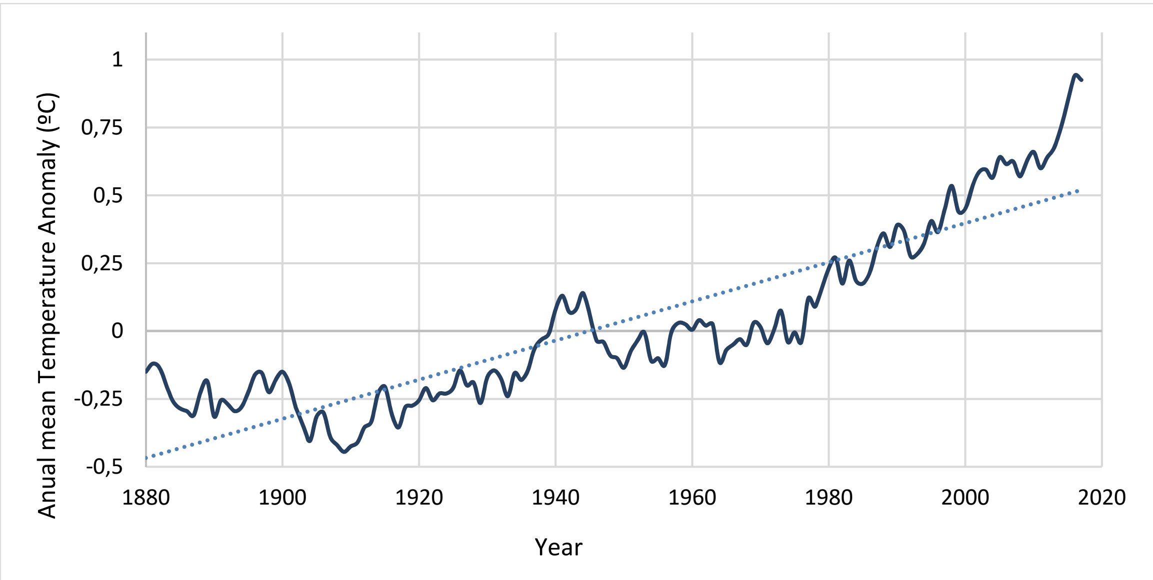
Data source: National Oceanic and Atmospheric Administration.

Most of the latest world's emissions result from human activities such as Industry, Buildings construction, Energy production, Using of energy, Agriculture and Transportation.

One consequence due to the "humanity illness" is the greenhouse (GH) effect caused for all gases accumulation in the atmosphere. In consequence, this can provoke that the terrestrial average temperature increases and, if this situation is kept in the time, there takes place what we name global warming and climate change; the habitual living conditions are modified and put in risk on ecosystems and species. The Intergovernmental Panel on Climate Change's (IPCC) major report on the science of climate change predicts that temperatures will rise by 2°C and 4.5°C by 2100, relative to pre-industrial temperatures if actual governmental policies don't change.

Graphic 2 supports the theory explained above, the change in global surface temperature relative to 1951-1980 average temperatures. Seventeen of the 18 warmest years in the 136-year record all have occurred since 2001, except for 1998. The year 2016 ranks as the warmest on record.

Graphic 2. Change in global surface temperature relative to 1951-1980 average temperatures.



Data source: NASA's Goddard Institute for Space Studies (GISS).

2.1.1.2 Emissions from Transport Sector

Transport Sector has a huge importance in the greenhouse gases emission over the world, as the International Energy Agency (IEA) published in Global EV Outlook (2017) Transport Sector currently accounts for 23% of global energy-related to GHG emissions, 73 % of which came from road transportation.

According to ITF Transport Outlook (2017) the CO_2 emissions generated by the Transport Sector would increase 60% in 2050. According to the forecast, motorised mobility demand in cities will be doubled between 2015 and 2050. The percentage of the private vehicles will be strongly growing in underdeveloped areas and softly decreasing in the developed economies areas but net flow represents a huge general growing.

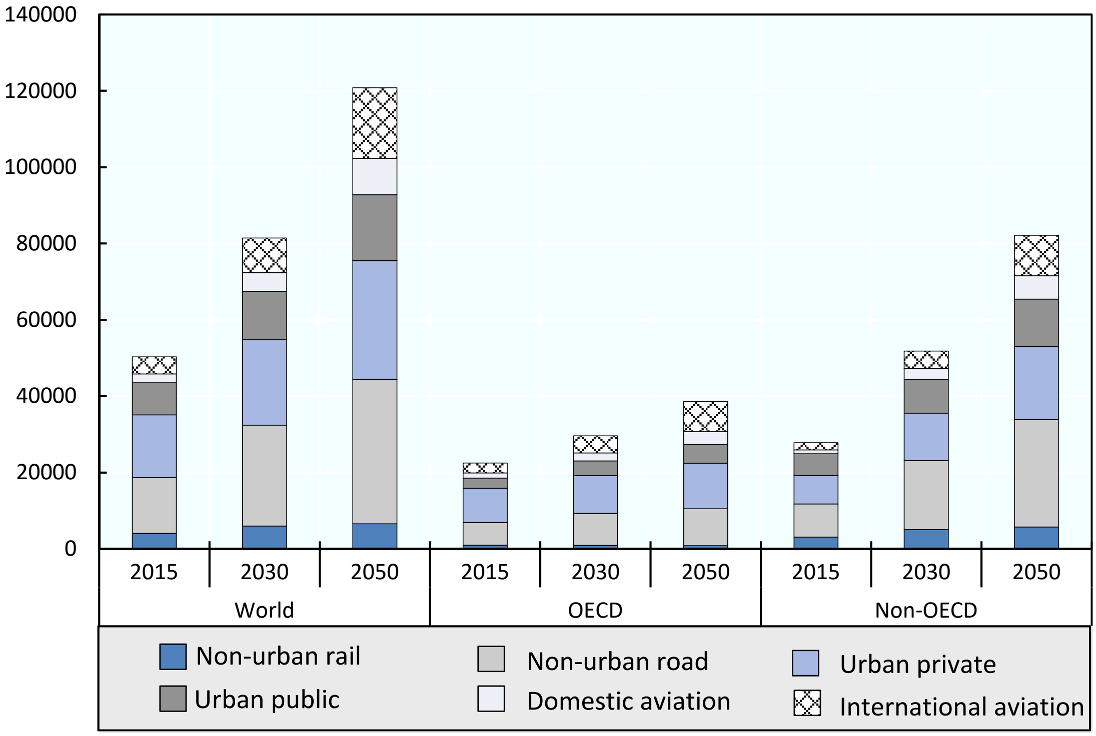
2.1.1.2.1 Transport global demand forecast

Global passenger demand will more than double between 2015 and 2050 from 50000 to 12000 billion passenger-kilometres (graphic 4). It will increase in every region and for every mode, but the growth is not uniformly distributed. Most of the growth occurs in Asia, which will represent around a third of all passenger transport demand in 2050. However, a low growth rates are observed in all OECD countries will only represent 25% of travel demand in 2050, compared to 45% in 2015. In the same way, all mobility modes don’t grow at the same manner and speed.

The countries that belong to OECD represent the countries most developed in relation to the global world economy, also those who have a more developed vision of future in terms of energy. It is necessary to transmit and impose preventive solutions to the countries that do not belong to OECD because they are those who are going to suffer a major emission increase during next years due to his future development.

As we can see below in the Graphic 3, demand for passenger transport in OECD countries will increase approximately half portion of the total increase of the non-OECD countries by 2050. Specially the non-urban mode of transport due to developing procedure consequence.

Graphic 3. Demand for passenger transport by mode forecast until 2050.
Units: Billion passenger-kilometres



Note: International passenger numbers are divided equally between the country of origin and the country of destination.

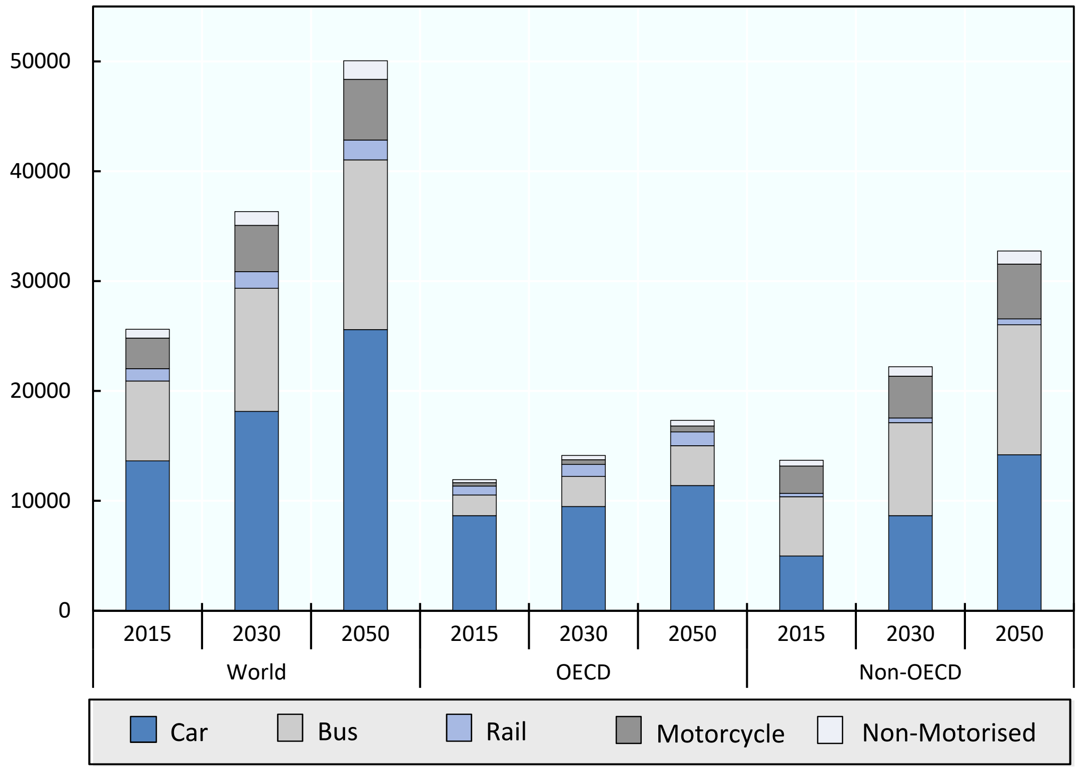
Data source: Dube, C., & Gumbo, V. (2017). Diffusion of Innovation and the Technology Adoption Curve: Where Are We? The Zimbabwean Experience. *Business and Management Studies*, *3*(3), 34. https://doi.org/10.11114/bms.v3i3.2500

As we can see in the graphic 3, most percentage of global growing mobility is the Urban private and non-urban road mobility, both mostly made up of burn-fuel vehicles.

Focusing on urban mobility, especially in developing countries, the process of urbanisation is taking place year after year. In 2050, 66% of the population will be urban, up from 54% in 2017. So, the demand for urban travel will grow, according to ITF Transport Outlook (2017) it will be 95% higher in 2050 than 2017, reaching more than 50000 billion passenger-kilometres that year. The most important urban mobility increase will be in developing countries because of the strong urbanisation process. Furthermore, OECD countries only marginally evolves, Asian cities, for instance double in size to represent the 20% of the world population in 2050. By 2050 mobility by car will only grow 32% in OECD countries against 185% in non-OECD countries.

In the next graphic, we can observe car motorised vehicles as most chosen option for urban mobility. Specially in OECD countries, the mobility option as car is the most used by a huge difference over others mobility modes.

Graphic 4. Urban passenger-kilometres by mode.
Units: Billion passenger-kilometres



Data source: Dube, C., & Gumbo, V. (2017). Diffusion of Innovation and the Technology Adoption Curve: Where Are We? The Zimbabwean Experience. *Business and Management Studies*, *3*(3), 34. https://doi.org/10.11114/bms.v3i3.2500

As we saw in the demand for passenger transport forecast (Graphic 3), one of most percentage growing mobility is Urban private and non-Urban road. In Graphic 4 we realise that the most urban transport demand in OECD countries is the car by a huge difference while in non-OECD countries the Bus have almost the same percentage but the car keeps represent a big part of urban mobility mode, however, both urban transport modes are composed by motorised vehicles. Thus, technological innovations such as the establishment of electrical vehicles (E.V), autonomous vehicles or the shared mobility solutions would change radically the boundary conditions of mobility, specifically in huge cities. For example, if all those billion passenger-kilometres shown in the graphic above related to road mobility were an increase of electric vehicles instead of burn-fuel vehicles, the impact of the CO_2 increase would be extremely lower.

2.1.1.2.2 CO_2 transport emissions to 2050

One of the most successful outcomes from the twenty-first session of the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) is the adoption of the *Paris Agreement.* This process has created a political pathway for climate change mitigation efforts by setting up a five-year review cycle for national decarbonisation commitments starting in 2020. Out of all the Nationally Determined Contributions (NDCs) accorded, 75% acknowledged the Transport Sector's role. Some of the more commonly found commitments include public transport improvement, the use of low-carbon fuel, the establishment of national mode share, energy consumption or renewable energy targets and the development of *electric mobility.*

Political and governmental measures are greatly needed as emissions from the Transport Sector, divergently to other sectors, transport emissions still growing and only a few recently started to decrease in developed countries. As we can see in Graphic 6, In 2015, CO_2 emissions from the Transport Sector amounted to 8000 billion tonnes, the same as almost 20% of the all man-made emissions. Leaving aside international modes, which are difficult to allocate to individual countries, CO_2 emissions in OECD countries amounted to slightly less than 4 billion tonnes in 2015, representing 42% of all CO_2 emissions related to transport. Focusing on per-capita terms, this is translated into approx. 3 tonnes of CO2 per inhabitant per year, against 0.5 for non-OECD countries (Table 1). According to ITF transport Outlook (2017) baseline scenario emissions, is a projection of current trends and includes current policies and policy developments increase 60% by 2050. Emissions from freight increase most and represent half of all emissions in 2050. This alarming evolution takes place despite the large expected gains in energy efficiency. However, freight road transportation would also be transformed in electrical vehicles, using for this sector electrical vans and lorries, having a huge impact on the stabilization of the CO_2 increasing emissions.

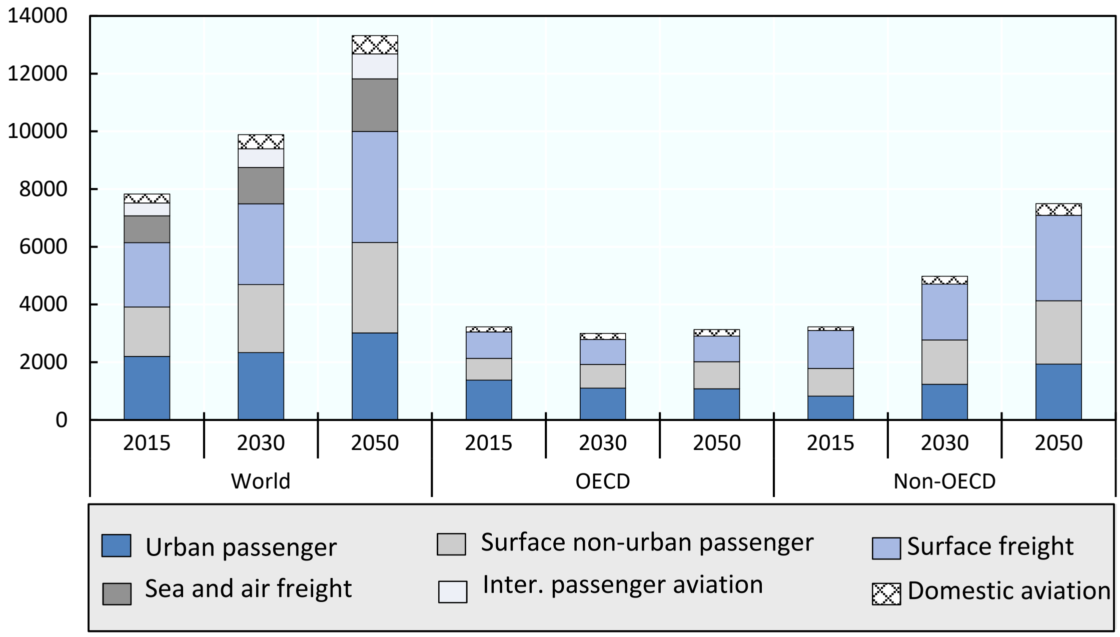
Certainly, the average CO_2 intensity of transport decreases significantly between 2015 and 2050. In the baseline scenario, passenger travel emits 60g of CO_2 per passenger-kilometre in 2050 on average, compared to 100g in 2015. Similar improvements occur for the freight sector. However, because of the expected strong growth in transport demand, this is far from sufficient to stop the growth in emissions.

Table 1. Emissions per capita from transport forecast, baseline scenario.
Units: Tonnes of CO_2 per inhabitant and per year

	2015	*2030*	*2050*
Domestic modes			
OECD	3	2.2	1.8
Non-OECD	0.5	0.8	0.9
International modes	0.2	0.3	0.4

Data source: Dube, C., & Gumbo, V. (2017). Diffusion of Innovation and the Technology Adoption Curve: Where Are We? The Zimbabwean Experience. *Business and Management Studies*, *3*(3), 34. https://doi.org/10.11114/bms.v3i3.2500

Graphic 5. CO_2 emissions by Transport Sector forecast, baseline scenario.
Units: Million tonnes



Data source: Outlook, I. T. F. Transport. 2017. *ITF Transport Outlook 2017*.

As we can see in Graphic 6, OECD emissions will be softly reduced (1.85%) while Non-OECD emissions will highly increase (132.3%). By 2050, CO_2 emissions due to motorised and fuel-burning vehicles will be 75% of the global transport sector emitting 61 % more CO_2 than 2015.

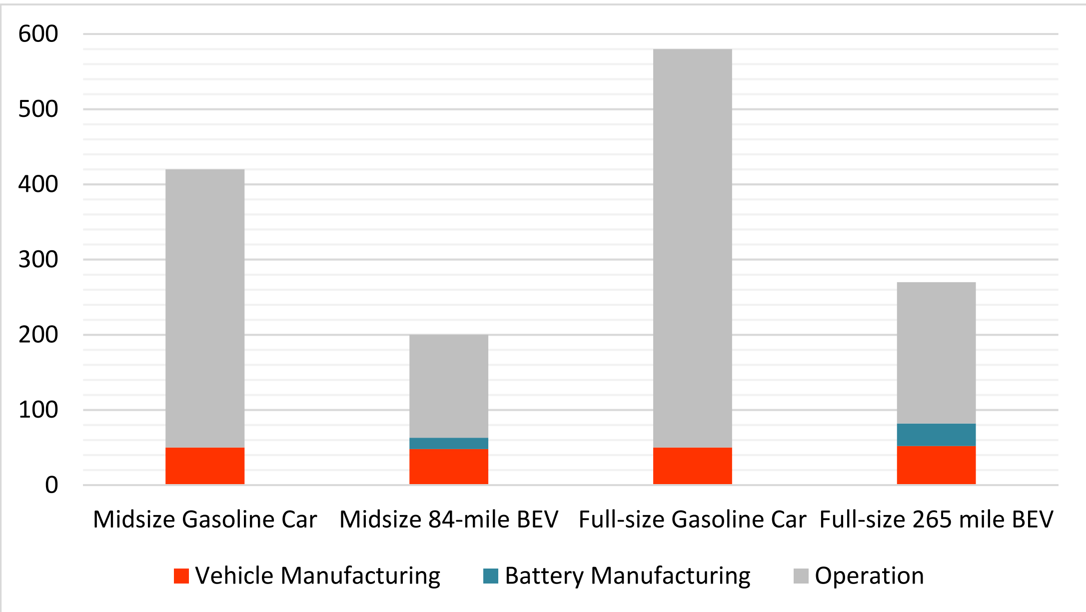
2.1.2.2.3 Life Cycle CO2 Emissions from the Manufacturing and Operation of Gasoline and Battery-Electric Vehicles.

In the study of the CO_2 emissions comparison between the Gasoline and Battery-Electric Vehicles (EV) is very important to differentiate the origin of the whole emissions.

Total emissions in the whole life cycle of the vehicle, in both cases, are emitted during the manufacturing process and operational process. It is a common error not to focus on the manufacturing process and just analyse the operational one. Deepening in the process, manufacturing is all the process to create and ensemble all the pieces of the car, as the battery manufacturing is more complex and composed by chemical materials, it is expected to generate more emissions than the normal combustion motor. About the operational process, it means all the car use done by the consumer and depend on the consumer and all the emissions generated to produce the electricity to charge the vehicles, depending of the effectiveness of each country, different ratio of emissions can be obtained depending of the manufacturing country, an average of both variables is used in Graphic 6.

An analysis realised by the Union of Concerned Scientists (2015) is shown in the next graphic, the comparative is done by a medium size vehicle and big size of the both modes of mobility.

Graphic 6. Life Cycle Global Warming Emissions from the Manufacturing and Operation of Gasoline and Battery-Electric Vehicles.
Units: grams of CO_2e per mile.



Data source: Nealer, Rachael, David Reichmuth, and Don Anair. 2015. "Cleaner Cars from Cradle to Grave: How Electric Cars Beat Gasoline Cars on Lifetime Global Warming Emissions." *Union of Concerned Scientists* 1–54.

Note from the "How Electric Cars Beat Gasoline Cars on Lifetime Global Warming Emissions (2015)": *"We assume that the midsize vehicles are driven 135,000 miles over their lifetimes and the full-size vehicles 179,000 miles. Midsize 84-mile EV is a five-seat car that travels 84 miles when fully charged, and Full-size 265-mile EV a full-size five- to seven-seat car with a range of 265 miles. We further assume that a consumer buying a EV would drive it the same total of miles as a corresponding gasoline vehicle. We use U.S. average electricity grid emissions to estimate manufacturing emissions, while the average electricity grid emissions intensity during vehicle operation are based on a sales-weighted average of where EVs are being sold today".*

Emissions produced during the manufacturing process of the vehicle, in both cases, mid-size and full-size, electric vehicle ones are bigger than the combustion vehicles, respectively 15% and 33%. However, this "extra-emissions" are easy justifiable with the operation process. According to Union of Concerned Scientists (2015) driving 6 months both type of vehicles, gasoline vehicles will start to emit more than electric vehicles in both cases, mid and full size. As we can see in the Graphic 6, operational emissions are hugely reduced in electricity vehicles respect to gasoline vehicles. So, nowadays electrical vehicles are emitting 51% less global warming emissions in the whole life cycle than the gasoline vehicles in the mid-size case, and 53% in full-size case.

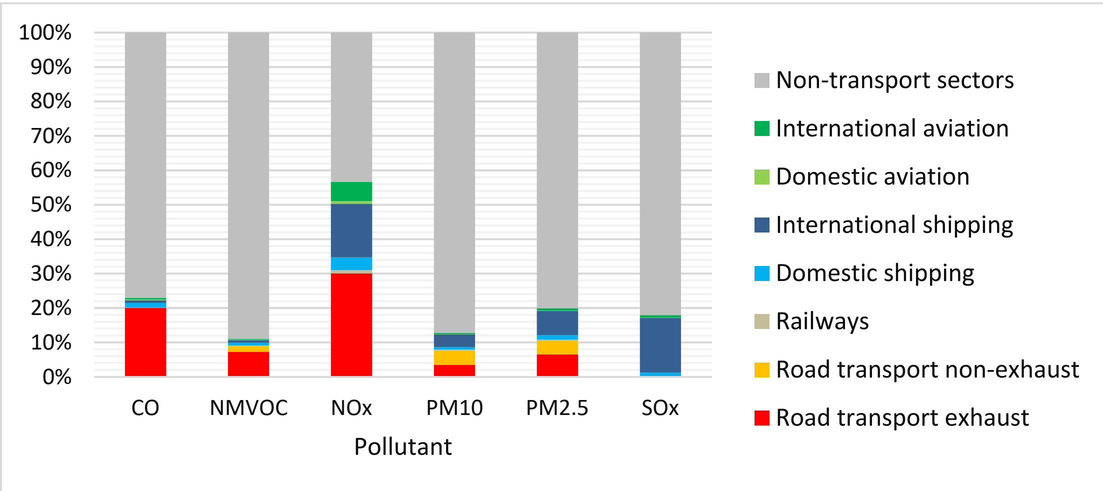
We should take in account that the emissions produced by electric vehicle operation are, ones emitted to generate electricity to power the vehicle, will suffer a constant decrease proportionally as the renewable energies increase their proportion in electricity generation. If the electricity responsible to feed the grid of the electrical fleet vehicles would be created by 100% renewables energy, operation emissions from electrical vehicle would be non-existent and the reduction of global warming emissions would be greatly decreased.

2.1.2.2.4 Air pollutants emissions from transport forecast

In addition to its climate change impacts, urban transport is an important contributor to local air pollution, principally through the emission of air pollutants such as carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PMø10 µm&PM ø2.5 µm), volatile organic compounds (NMVOC) and sulphur oxides (SOx). Those are emitted into the environment some non-exhausted, vehicle parts and pneumatic rests can be an example, and others directly exhausted by motorized vehicles which can contribute to severe health problems, including cardiovascular and respiratory diseases and numerous cancers. These problems are widespread: The World Health Organisation estimates that more than 90% of the world population lives in area where air pollution is above the limits for healthy living (WHO, 2016)

The effects of urban activity on CO_2 and local air pollutants are not always correlated. While emissions of CO_2 are strictly proportional to fuel consumption, the quantity of local pollutants per litre of fuel in exhaust fumes can vary greatly. Regulation has historically focused on limits on tailpipe emissions, because it was assumed that consumer pressure would result in fuel efficiency gains, and thus in less CO_2 emissions. While there is a controversy regarding differences in the level of emissions of local pollutants between test and on-road conditions, the strengthening of emission standards means that, in the European Union, new passenger cars in 2014 emit 100 times less PM than new cars in 1996. It is estimated that the most advanced emission controls could effectively eliminate over 99 percent of local air pollutants from engines, but, what if the vehicle type is totally changed by electrical vehicles and 100 percent of those local air pollutions are "eliminated".(ITF transport Outlook 2017).

Graphic 7. Contribution of the transport sector to total European emissions of the main pollutants (2015)
Units: Percentage (%)



Data source: European Environment Agency (EEA) 2017.

Table 2. Contribution of the transport sector to total European emissions of the main pollutants values (2015)
Units: tonnes and Percentage

POLLUTANTS	*R.T Exhaust*	*R.T Exhaust (%)*	*R.T non-exhaust*	*R.T non-exhaust (%)*	*Total*
CO	47080	20,06	0	0,00	234700
NMVOC	5840	7,28	1390	1,73	80170
NOx	33620	30,05	0	0,00	111870
PM10	1010	3,45	1240	4,23	29290
PM2.5	930	6,52	570	3,99	14270
SOx	60	0,10	0	0,00	57520
TOTAL	88540	**16,77**	3200	**0,61**	527820

Data source: European Environment Agency (EEA) 2017.

As we can observe in the Graphic 7 and Table 2, in European context, the major proportion of the pollutants is emitted through Road transportation exhaust & non-exhaust, as a global view a 16.77% and 0.61% respectively.

Values below would not seem to have a huge impact but if pollutants are analysed individually, percentages of 30% in the case of nitrogen oxides (NO_x) and 20% in the case of carbon monoxide (CO) are shown. These proportions have a huge impact on the total European emissions.

As we could observe in the graphic 4, a 53.2 % over the total urban transportation is composed by cars in 2015 and remind stable up to 51.11% to 2040 in the reference scenario. Then, with this information we can obtain the percentage of the air pollutants emitted by cars in urban European zones, shown in Table 3.

Table 3. Contribution of Urban cars in total European emissions of the main pollutants (2015 values)
Units: Tonnes and Percentage (%)

POLLUTANTS	*U.C Exhaust*	*U.C Exhaust (%)*	*U.C non-exhaust*	*U.C non-exhaust (%)*	*Total*
CO	25093,64	10,69	0	0,00	234700
NMVOC	3112,72	3,88	739,48	0,92	80170
NOx	17919,46	16,02	0	0,00	111870
PM10	538,33	1,84	659,68	2,25	29290
PM2.5	495,69	3,47	303,24	2,13	14270
SOx	31,98	0,06	0	0,00	57520
TOTAL	47191,82	**8,94**	1702,4	**0,32**	527820

Data source: Outlook, I. T. F. Transport. 2017. *ITF Transport Outlook 2017*,European Environment Agency (EEA) 2017.

It should be taken in account the optimistic character of this approximation in comparison with the rest of the world, because Union Europe belong to OECD and as we have seen in graphic Y the growing of the transport demand is not as huge as Non-OECD.

With the E.V establishment can be reached a decrease of 8,94% of the pollutants due to road transportation exhaust because E.V don't have an exhausting system of pollutants. However, a study of road transportation non-exhaust pollutants hasn't been done yet. We must keep in mind that E.V still giving off non-exhausting pollutants because of their cycle of using.

Nevertheless, the emissions due to the road transportation exhaustion are much bigger than road transportation non-exhaustion emissions, for this reason the E.V establishment keep having a huge impact in the reduction of the air pollutants.

2.1.1.3 Paris Agreement on climate change

Paris Agreement joint developed and developing countries to make significant commitments to address climate change. All the agreement members represent 97% of global emissions, all of them have already promised their Nationally Determined Contributions (NDCs) for how they will address climate change. Every country will review their current pledges by 2020 and, ideally, reinforce their emission reduction targets for 2030 because they could discover that they can achieve more aggressive action than they envisioned at this moment. The Paris Agreement includes total transparency and accountability system for all countries involved in it, indeed, it requires reporting on GHG inventories and projections that are subject to a technical expert review and multilateral examination. Countries, will continue to provide “climate finance” to help the most vulnerable countries to adapt to climate change and build low-carbon economies. This point is one of the most representative and important of the Paris Agreement, as seen in Graphic 6, biggest emissions are emitted by non-OECD countries which represent less favourable economies and developing countries.

Countries, will start a review process which countries outline their next set of commitments every five years, beginning in 2018 and every five years thereafter, countries will have a chance to take stock of the aggregate effort of all national pledges to determine if the world can keep the global average temperature to well under 2 degrees Celsius rise from pre-industrial levels. This is one of the most critical outcomes of the Paris Agreement.

As an outcome of the Paris Agreement, developing countries will be assisted in reducing the emissions and adapting to the impacts of climate change. Paris Agreement conclude to act and implement over time with a collective mobilization commitment on finance of $100 billion annually, through 2025. Developed countries, prior to 2025 would set a new collective quantified goal of mobilizing at least $100 billion for climate finance Other countries are encouraged to also help mobilize finance. To provide predictability on climate finance, developed countries will communicate every two years on projected levels of public climate finance for developing countries, while developing countries will report on climate finance on a voluntary basis. Regular updates send a signal for where low-carbon investments can be made, and the resources available to help the most vulnerable communities adapt to climate change (Natural Resources Defence Council, The Paris Agreement on Climate Change (2017).

2.1.2 Crude Oil is not a renewable energy

Crude oil was formed from the remains of animals and plants (diatoms) that lived millions of years ago in a marine environment before the existence of dinosaurs. Over millions of years, the remains of these animals and plants were covered by layers of sand, silt, and rock. Heat and pressure from these layers turned the remains into what we now call crude oil. The word *petroleum* means *rock oil* or *oil from the earth.*

Crude oil, coal, nuclear and natural gas are all considered fossil fuels, not renewable energies.

2.1.2.1 Crude Oil consume forecast

2.1.2.1.1 Crude Oil future scenarios by IEO (2017)

According to the International Energy Outlook (2017) we assume three possible scenarios for the uncertainty of the future oil prices. The effects of economic growth assumptions on energy consumption are addressed in the High and Low Economic Growth cases. World gross domestic product increases by 3.3%/year from 2015 to 2040 in the High Economic Growth case and by 2.7%/year in the Low Economic Growth case, compared with 3.0%/year in the Reference case.

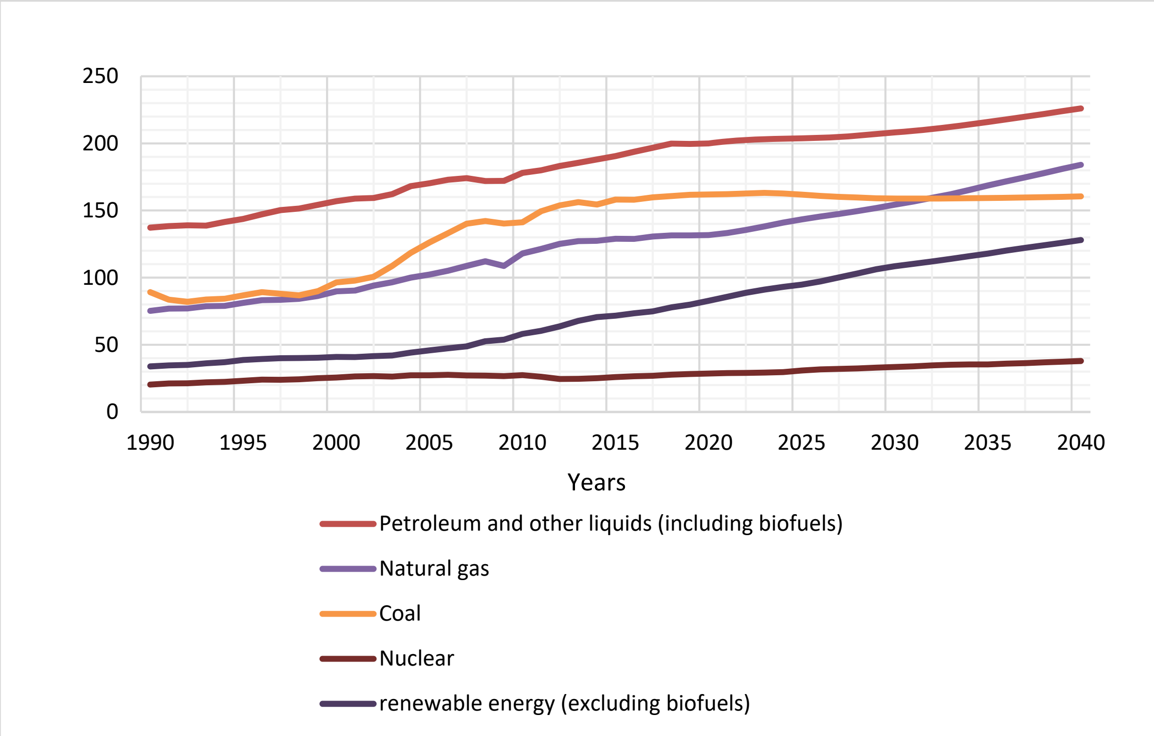
Another difference between those scenarios is the High and Low Oil Price cases address the uncertainty associated with the trajectory of world energy prices. In the Low Oil Price case, the price of North Sea Brent crude in 2016 dollars reaches $43/barrel by 2040, compared with $109/barrel in the Reference case and $226/barrel in the High Oil Price case.

The Reference case assumes continual improvement in known technologies based on current trends and relies on the views of leading economic forecasters and demographers related to economic and demographic trends for 16 world regions based on OECD membership status.

2.1.2.1.2 Energy consumption of petroleum forecast

As we can see in the Graphic 8, the world energy consumption of petroleum is the highest in comparation with other fuels. Having in account no further changes in the actual governmental policies, reference case, petroleum and other liquids, which means crude oil and lease condensate and other liquid fuels, including bio-fuel, responsible too for CO_2 emissions, will keep increasing their consumption by 2040.

Graphic 8. World energy consumption by energy source, reference case
Units: Quadrillion btu (Brithish Thermal Unit, 1Btu= 1.060 kJ= 0.25 kcal)



Data source: EIA. 2017. "International Energy Outlook 2017 Overview." *U.S. Energy Information Administration* IEO2017(2017):143.

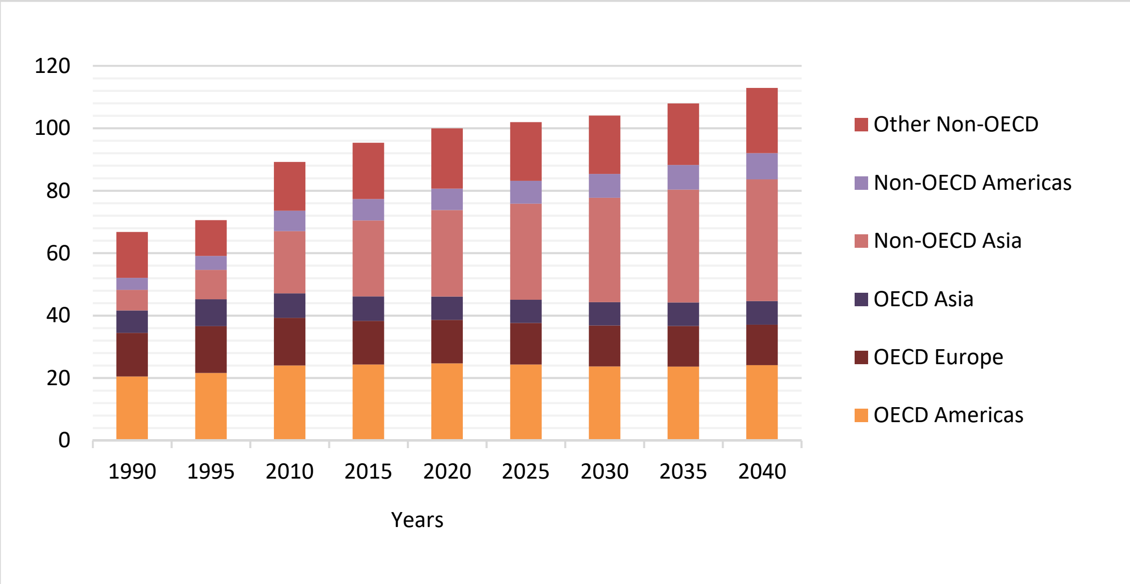
Although renewable energy and nuclear power are the world's fastest growing forms of energy, fossil fuels are expected to continue to meet much of world's energy demand.

Petroleum and other liquids remains the largest source of energy, but as IEO (2017) shows, its share of world marketed energy declines from 33% in 2015 to 31% in 2040 but on a worldwide basis, liquids consumption increases in the industrial and transportation sectors, and declines in the electric power sector.

Growing of world energy consumption of petroleum pretend not to be uniform. As we have said in other parts of the project, the industrialization and developing procedure is happening in non-OECD countries, which in the reference case, will be again the consequence of the huge growing of the world energy consumption of petroleum, Graphic 9 supports this assumption.

Graphic 9. Petroleum and other liquids consumption, reference case.

Units: Million barrels per day.



Data source: EIA. 2017. "International Energy Outlook 2017 Overview." *U.S. Energy Information Administration* IEO2017(2017):143.

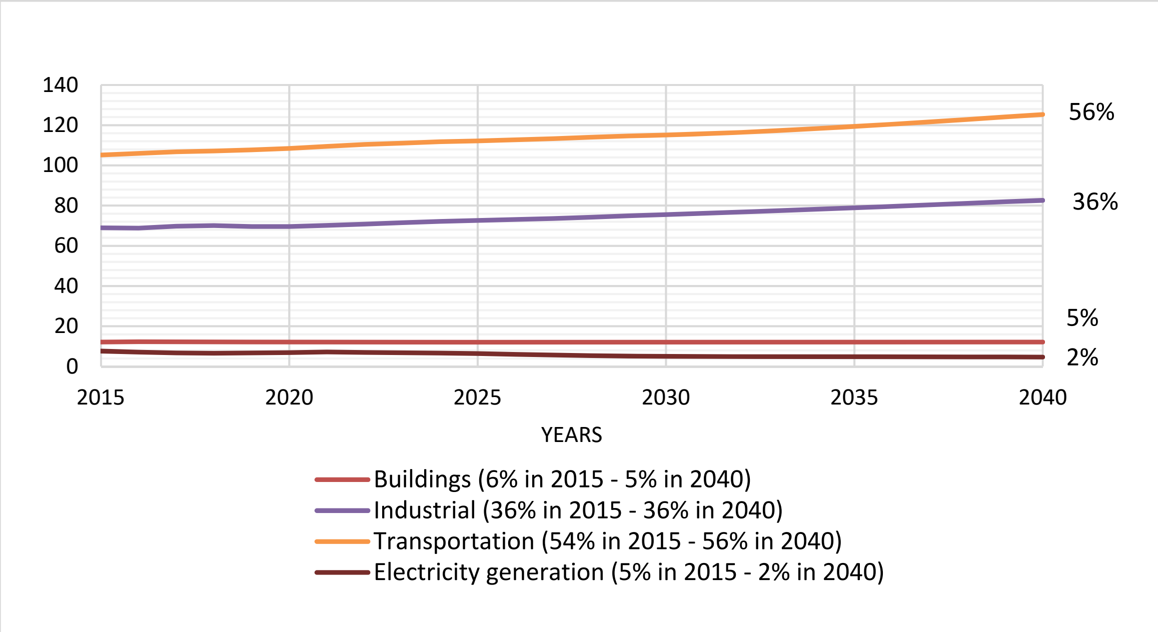
Most of the growth in world liquid fuels consumption from 2015 to 2040 comes from non-OECD countries, where strong economic and population growth increase the demand for liquid fuels by 39%. Overall OECD consumption of liquid fuels decreases by 3%. More than 80% of the total increase in liquid fuels consumption is in non-OECD Asia, as China and India experience rapid industrial growth and increased demand for transportation. China's use of liquid fuels for transportation is projected to increase by 36% from 2015 to 2040 and India's use over that period increases by 142%. In OECD countries, demand for liquid fuels grows slowly or declines between 2015 and 2040.

2.1.2.1.3 Refined petroleum and other liquids consumption by end-use sector

In the Graphic 10 below, we can appreciate the world energy consumption of refined petroleum and other liquids by end-use sector forecast made for the U.S Energy information administration (EIA) until 2040.

Graphic 10. Refined petroleum and other liquids consumption by end-use sector, reference case.

Units: Quadrillion btu (Brithish Thermal Unit, 1Btu= 1.060 kJ= 0.25 kcal)



Data source: [Source: EIA. 2017. "International Energy Outlook 2017 Overview." *U.S. Energy Information Administration* IEO2017(2017):143]

According to EIA the transportation sector remains the largest consumer of refined petroleum and other liquids as their use for travel and freight services increases at a faster rate than their use in other applications between 2015 and 2040. Petroleum and other liquids are used in the industrial sector to power equipment, serve as chemical feedstocks, and provide industrial heat. These uses increase slowly between 2015 and 2040. The use of liquid fuels in buildings, mainly liquefied petroleum gas (LPG) to provide space heat in regions where natural gas infrastructure is less developed, is nearly flat from 2015 to 2040. The use of petroleum and other liquids to generate electricity declines over the projection as various factors, including increasing oil prices and relatively less costly natural gas, encourage producers to switch to alternative energy sources.

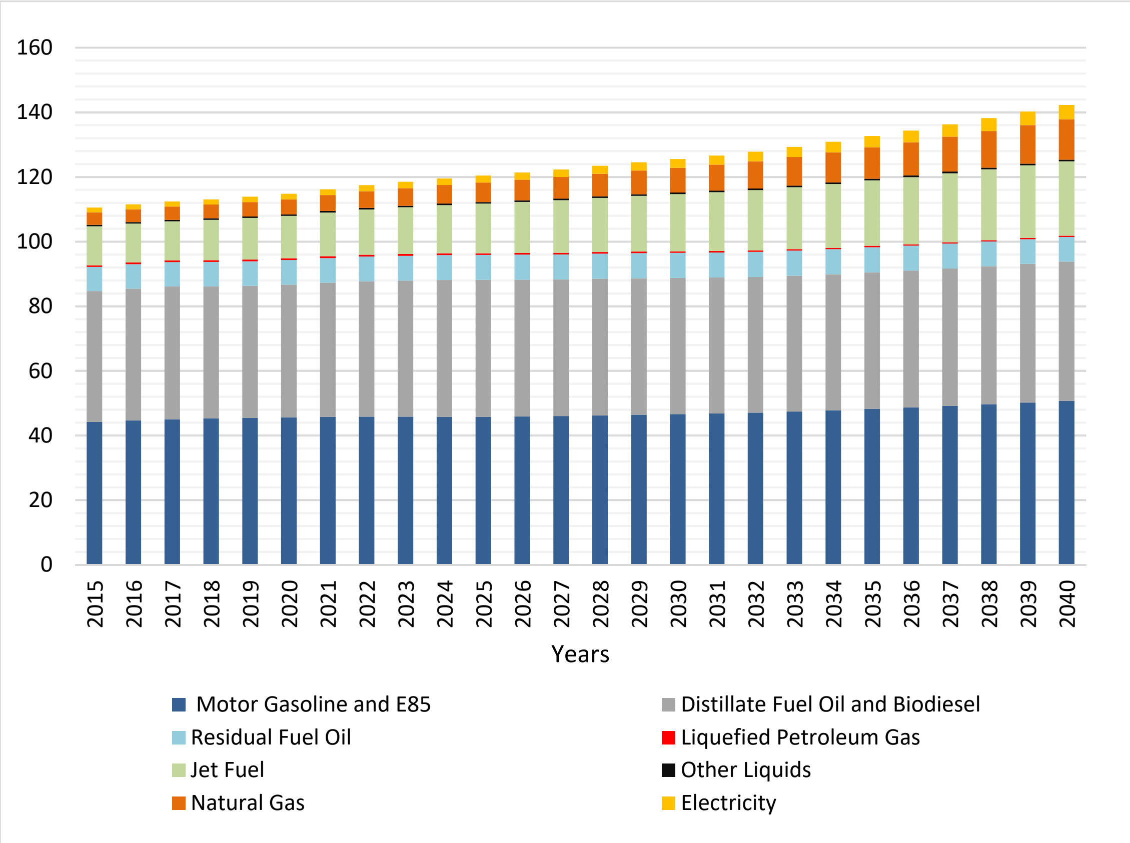
2.1.2.2 Transportation energy consumption

The principal aim of this section is to investigate which energy does the world use to feed transportation and which part of each source of energy is used in a global vision. Using this information is possible to know if the establishment of electric vehicles have a controversy result using electricity as the principal energy for mobility and not fuel-burn combustible.

2.1.2.2.1 World transportation energy consumption by source

In Graphic 11 is seen the world transportation energy consumption by type of source, motor gasoline, diesel, jet fuel, natural gas and electricity. Remember that motor gasoline, diesel and jet fuel are all oil-derivates.

Graphic 11. World transportation energy consumption by source, Reference case. Units: Quadrillion btu (Brithish Thermal Unit, 1Btu= 1.060 kJ= 0.25 kcal)



Data source: [Source: EIA. 2017. "International Energy Outlook 2017 Overview." *U.S. Energy Information Administration* IEO2017(2017):143]

Observing Graphic 11 a huge increase in the total world transportation energy consumption is not appreciate between 2015 and 2040, the worldwide transportation sector accounts for 55% of total end-use sector liquid fuels consumption in 2040, about the same as its share in 2015, as we can double check with the percentage shown in Graphic 10.

As another prove of the CO_2 constantly increasing emissions fuel-burn types of fuel keep increasing and representing huge percentage of the total transportation energy consumption, according to IEO (2017) the use of refined petroleum and other liquid fuels in the transportation sector continues to increase through 2040, but proportionally it decreases a 7%, from 95% to 88%, because of the alternative fuels slowly increase. Motor gasoline, including biofuel additives, remains the primary fuel for transportation, accounting for 36% of the world's transportation-related energy use in 2040.

Natural gas and electricity, while starting from much lower levels of use than liquid fuels in the transportation sector, are the fastest-growing forms of transportation energy use, with consumption of each approximately tripling between 2015 and 2040. Natural gas consumption for passenger and freight transportation increases nearly 500% from 2015 to 2040, up nearly 8 quadrillion Btu.

An important point to keep is that electricity represents only the 3% of the total transportation energy consumption in 2040 with an improvement of an 197% by 2015. This fact flush that Electricity have a lot of potential to grow and substitute other sources of energy. With the establishment of the electrical vehicles all over the world in not a very far future electricity energy could substitute much percentage of use of refined petroleum and other liquid fuels in the transportation sector.

As IEO (2017) is repeating in every report, Non-OECD Asia, which includes China and India, accounts for more than 70% of the increase in transportation fuel used in non-OECD countries as increased demand for personal transport from growing middle classes largely outpaces vehicle efficiency gains. As consumers increase their demand for personal transportation, including the use of light-duty and of 2- and 3-wheel vehicles, motor gasoline consumption grows more than any other transportation fuel.

On a percentage basis, natural gas used as a transportation fuel experiences the fastest growth over the projection period, driven by increased use in large truck and bus fleets.

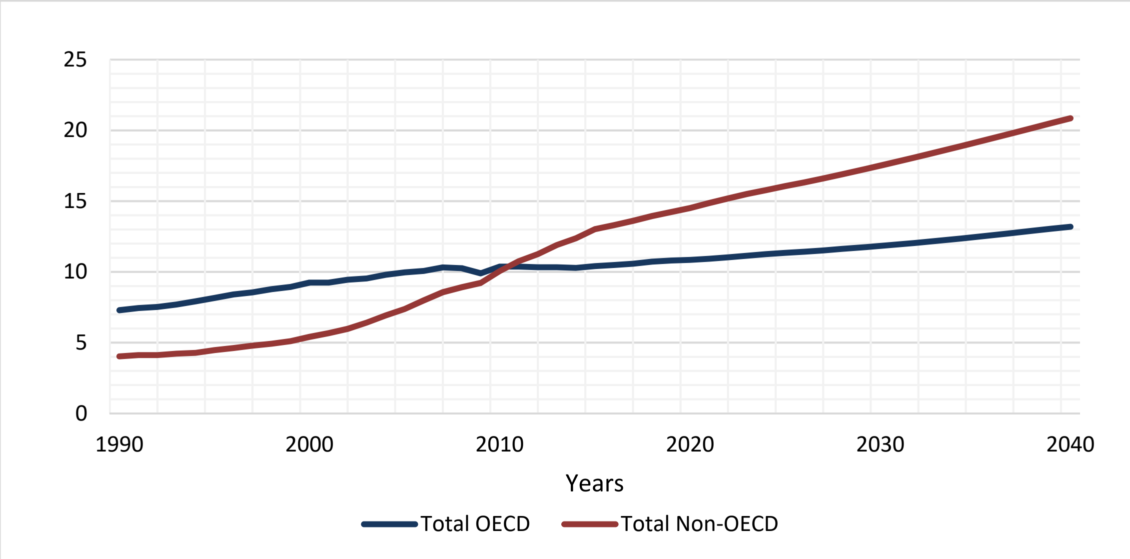
2.1.2.3 Electricity generation

One of the most important issues to study about the transportation based in Electrical Vehicles is the origin of their power, the electricity generation. Thus, we can understand that the establishment of the E.V is not a controversy in terms of energy and to generate the sufficient amount of electricity to provide power to all fleet of electrical vehicles is not spending the same quantity of crude-oil that is used nowadays to provide energy to all the fuel-burn vehicles. We must remember that one of the E.V objectives is to extend the crude-oil life and be prepared to its ending, so, the last condition must be enforced to reach this objective.

2.1.2.3.1 Electricity generation OECD/Non-OECD

In the graphic above we can observe the difference in net electricity generation between OECD and Non-OECD from 1990 to 2040 in the reference case based on IEO (2017).

Graphic 12. OECD and non-OECD net electricity generation, reference case
Units: trillion kilowatt-hours

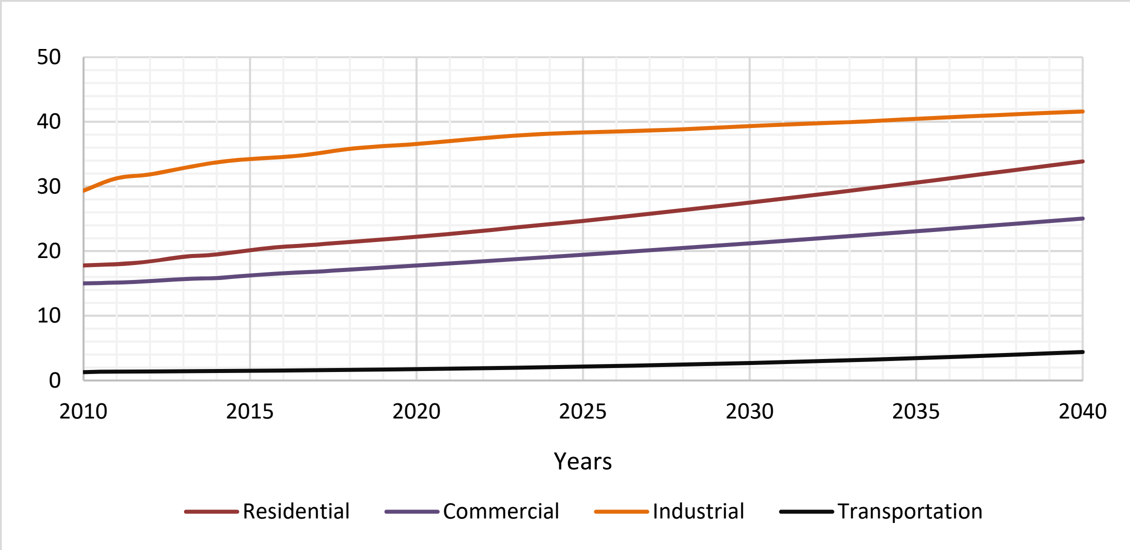


Data source: EIA. 2017. "International Energy Outlook 2017 Overview." *U.S. Energy Information Administration* IEO2017(2017):143

As an observation of the Graphic 12 produced using U.S Energy Information Administration data net electricity generation in Non-OECD countries increases an average 1.9%/year from 2015 to 2040, compared to 1.0%/year in OECD countries, almost double speed, that fact is produced because electricity use increases the most in residential and commercial buildings over the period of 2015–40 as personal incomes rise and as urban migration continues in non-OECD countries.

In Graphic 13, we can see the distribution of the electricity use globally generated, this information helps us to know which proportion of the generated electricity is used in transport sector. Thus, this information helps us to prevent the oversaturation of the transport sector in terms of electricity spent if it was the case.

Graphic 13. World electricity use by sector, reference case.
Units: Quadrillion btu (Brithish Thermal Unit, 1Btu= 1.060 kJ= 0.25 kcal)



Data source: EIA. 2017. "International Energy Outlook 2017 Overview." *U.S. Energy Information Administration* IEO2017(2017):143.

As we can observe in Graphic 13, the industrial sector is the one which world spent more proportion of the electricity generated. We can also observe that in the case of transport sector, a tiny percentage of the global generated electricity is aimed to it. However, this percentage is suffering an increasing process due to as more plug-in electric vehicles enter the fleet and electricity use for rail expands, but this share accounts for only 4% of total delivered electricity consumption in 2040.

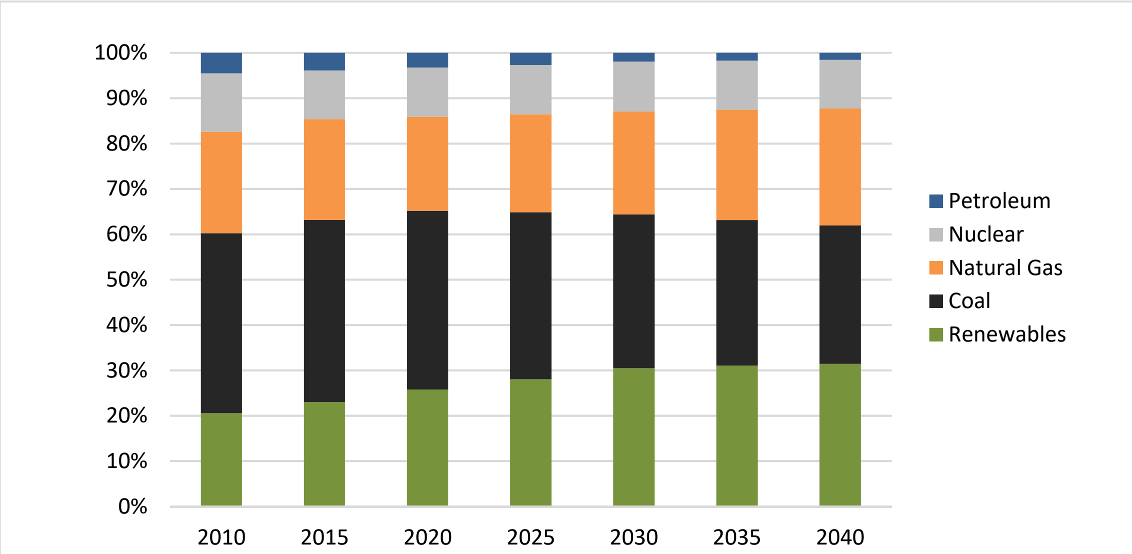
As a conclusion of this section, transport is a low profited sector in terms of electricity energy used, as a consequence and in the first view, we have a lot of road to obtain benefits. It's necessary to see if this electricity is generated as a not offensive way and if it is sustainable.

2.1.2.3.2 Share of electricity generation

This section is dedicated to analysing the origin of the world electricity generation to give an answer to the question mentioned above about "offensive and sustainability of the electricity generation".

Graphic 14 is showing us the origin of the electricity generation through percentages of all the possible sources of generation, also a forecast since 2010 to 2040, respectively is used the reference scenario proposed by IEO (2017)

Graph 14. Share of net electricity generation, reference case.
Units: Percentage



Data source: EIA. 2017. "International Energy Outlook 2017 Overview." *U.S. Energy Information Administration* IEO2017(2017):143.

As it can be seen in Graphic 14, in the reference case, renewable energies and natural gas will increase their share in the 2040 forecast, both combined will reach a 57% in 2040 respecting their share in 2015.

Separately, Renewables, including hydropower, are the fastest-growing sources of generation over the period of 2015 to 2040, rising by an average of 2.8%/year, as U.S Energy Information Administration claims "*technological improvements and government incentives in many countries support their increased use*".

Natural gas generation grows by an average 2.1%/year from 2015 to 2040, whereas nuclear generation grows by 1.5%/year.

Coal's generation share declines from 40% in 2015 to 31% by 2040 and in the same year renewables provide the same share of world electricity generation as coal at 31%.

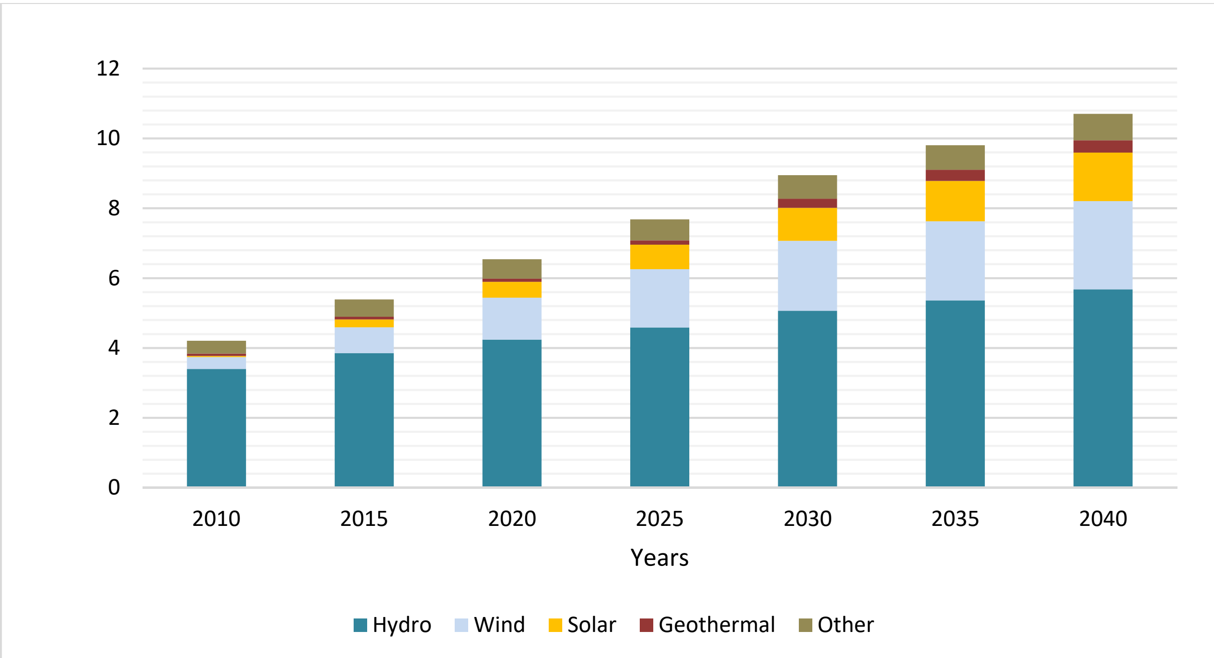
Last information is very important related to the establishment of the E.V due to renewable energies are the most sustainable and with less ambiently impact and $C0_2$ emissions related to their generation. Another important element is that each country can have the change to create independently their own renewable energies without having to deal with the international business. That fact reduces the energy dependence and increase the safety and stability of the internal economy.

2.1.2.3.3 World net electricity generation from renewable power

In the following section we will analyse the forecast generation of renewable energies and which percentage of each one is generated.

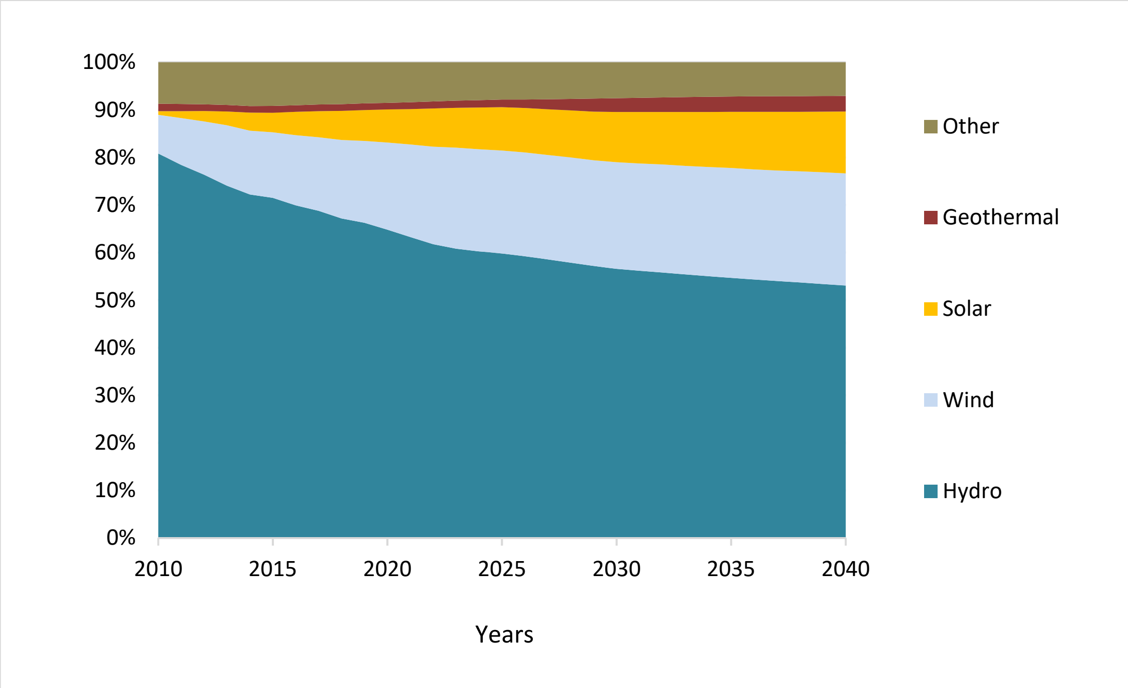
In Graphic 15&16 is shown the different renewable sources of electricity generation used globally, their proportion and increasing from 2010 to 2040 respectively to the reference case.

Graphic 15. World net electricity generation from renewable power
Units: trillion kilowatt-hours



Data source: EIA. 2017. "International Energy Outlook 2017 Overview." *U.S. Energy Information Administration* IEO2017(2017):143.

Graphic 16. World net electricity generation from renewable power.
Units: percent share of renewable energy



Data source: EIA. 2017. "International Energy Outlook 2017 Overview." *U.S. Energy Information Administration* IEO2017(2017):143

On one hand, Wind and solar dominate growth in renewables and represent over two-thirds of related capacity additions by 2040.

On the other hand, Hydropower's share of renewable generation falls from 71% in 2015 to 53% in 2040 as resource availability in OECD countries and environmental concerns in many countries limit the number of new mid- and large-scale hydropower projects. However, generation from non-hydropower renewables rises an average 4.9%/year from 2015 to 2040.

Among non-hydroelectric renewable energy sources, wind and solar increase the most over the period of 2015 to 2040, reaching 2.5 and 1.4 trillion kilowatt-hours, respectively, as these technologies become more cost competitive over time.

3. Technological concepts

Just as there are a variety of technologies available in conventional vehicles, plug-in electric vehicles have different capabilities that can accommodate different drivers' needs. A major feature of the plug-in electric vehicles is that drivers can plug them in to charge from an off-board electric power source. This distinguishes them from hybrid electric vehicles, which supplement an internal combustion engine with battery power but cannot be plugged in.

Apart of all specific engine technological concepts, the most important knowledge to follow explanations of this project are global technological concepts such as, different types of EVs and their average autonomy, different types and speed of charging those plug-in electric vehicles and where can they be charged. This information will provide the knowledge enough to understand why plug-in electric vehicles need to be charged in the fast charging stations explained in this section.

3.1 Types of EVs

Terminology of Electrical Vehicle can be very “exhaustive” and genera. Nowadays the following three general types of EVs are available.

Table 4. Types of EVs by Type of fuel, Plug-in and Electric range.

Name	Acronym	Type of fuel	Plug-in	Electric range in one charge (median)
Traditional Hybrid vehicles	HEV	Oil and Electricity	No	2km
Plug-in Hybrid Electric vehicles	PHEV	Oil and Electricity	Yes	16-65 km
Extended- Range Electric Vehicles	EREV	Oil and Electricity	Yes	16-65 km
Battery electric vehicles	EV	Electricity	Yes	200km

Data source: Dube, C., & Gumbo, V. (2017). Diffusion of Innovation and the Technology Adoption Curve: Where Are We? The Zimbabwean Experience. *Business and Management Studies*, *3*(3), 34. https://doi.org/10.11114/bms.v3i3.2500

1·Traditional hybrid vehicles (HEV)

Hybrid Electric vehicles (HEVs) are powered by both petrol and electricity. The electric energy is generated by the car’s own braking system to recharge the battery. This is called “regenerative braking”, a process where the electric motor helps to slow the vehicle and uses some of the energy normally converted to heat by the brakes. This type of electric vehicle cannot be plugged-in, the battery is only charged through the breaking system.

HEVs start off using the electric motor, then the petrol engine cuts in as load or speed rises. The two motors are controlled by an internal computer which ensures the best economy for the driving conditions. Depending on the model, hybrids operate in different ways. Some models must be used in dual power mode, where the electric battery serves to reduce the amount of petrol is used, others will store enough energy that the battery can be used to power the vehicle alone on short journeys or low speed, such as point to point travel within city.

2 · Plug-in Hybrid Electric vehicles (PHEV) & Extended-Range Electric Vehicles (EREVs)

Plug-in Hybrid Electric vehicles (PHEV), & Extended-Range Electric Vehicles (EREVs), are powered by both petrol and electricity sources of energy, combine an electronic motor with a traditional internal combustion engine. Both can recharge their battery through both regenerative braking and “plugging-in” to an external electrical charging station. The difference between PHEVs and EREVs is PHEVs are hybrids, often with longer-range battery capacity than non-plug-in hybrids, whose batteries can be charged by plugging them into an electrical outlet or charging station. PHEV engine is the result of the electric engine and fuel-burn motor working parallelly. This system works depending of the driving situation, for example in urban driving where the driving velocity is low, is it especially useful to decrease the noise and air pollutants. In EREVs the electric motor always powers the drivetrain wheels. However, when the battery reaches a certain level of charge, the gas motor kicks in to charge the battery providing the “extended range.”

According to U.S department of energy, PHEV own bigger batteries than HEV, which allow them to move with only electricity power with an autonomy between *16 and 65 kilometres* or even more in new actual models with light load. So, that while the electric battery is charged, an PHEV can work mainly with the socked electricity. The intern combustion motor can drive the vehicle when the battery is totally uncharged, in fast accelerations, when the vehicle reaches highs velocities or when AC or heating is needed in high potency.

3 ·Battery electric vehicles (EV)

Battery Electric Vehicles are those which run entirely on their electric battery, meaning they are only powered by electricity and do not have petrol engine, fuel tank or exhaust pipe. These types of cars charge the battery using external chargers, depending on the type of charger and the electricity power of it, the car will spend different time to completely charge the battery. This vehicle has a longer electric range than most of the PHEV vehicles.

The displacement autonomy of the actual BEH per charge is lower than the traditional vehicles per each oil tank. According to the U.S department of energy most of EV owns an autonomy of 200 *kilometres in median* with full-charged battery though some models reach larger autonomy until 500 km Tesla models (see table 4). BEH autonomy depends on the conditions and drive habit. External extreme temperatures tend to reduce the autonomy because of the energy wasted in feed the AC and heating systems and drive the motor. Driving in high velocities, driving imprudently and bringing heavy loads can reduce the autonomy too.

EV are the purest electric vehicle existing in the market, all the studies done in this project have been taking in account the disposition of EV as being the only one running with only electricity power, the truly aim of the project to reach the zero emissions vehicle. In the "EVES and demand circle" section of the project an autonomy analysis will be shown.

For further information we can see in table 5 the top 11 electric vehicles with more autonomy in 2018.

Table 5. Top 11 Electric vehicles with more autonomy available in 2018.

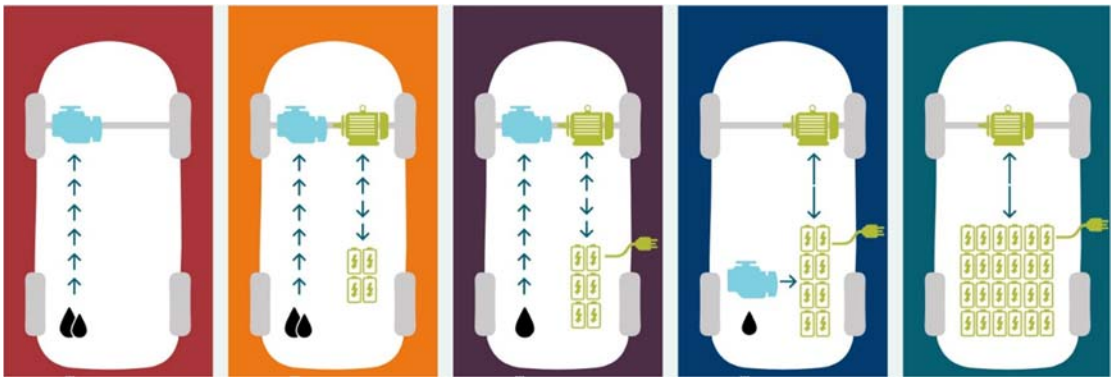
MODEL	ENGINE POWER	AUTONOMY (WLTP)	PRICE EUROPE (€)	FAST CHARGE	BATTERY CAPACITY	BATTERY GUARANTY
Renault ZOE ZE40 R90 / R110	92 / 109 CV	300 km	From 21.200	No	41 kWh	Unlimited
BYD E6 400	122 CV	300 km	54.895	Yes	82 kWh	5 Years
Hyundai Ioniq	120 CV	210 - 310 km	Available during 2018	Yes	28 - 39,2 kWh	8 Years / 200.000 km
Audi e-tron	503 CV	375 - 400 km	Available during 2018	Yes		8 Years / 160.000 km
Nissan LEAF	150 - 220 CV	270 - 400 km	Available during 2018	Yes	40 - 60 kWh	8 Years
Opel Ampera-e	204 CV	415 km	42.990	Yes	60 kWh	8 Years / 160.000 km
Tesla Model X	422 - 611 CV	320 - 430 km	98.830 - 158.430	Yes	75 - 100 kWh	8 Years
Hyundai Kona	135 - 204 CV	300 - 470 km	Available during 2018	Yes	39,2 - 64 kWh	8 Years / 200.000 km
Jaguar I-Pace	400 CV	480 km	79.100	Yes	90 kWh	8 Years / 100.000 km
Tesla Model 3	262 CV	400 - 500 km	35.000	Yes	55 - 80,5 kWh	8 Years / 200.000 km
Tesla Model S	422 - 611 CV	380 - 500 km	86.980 - 150.080	Yes	75 - 100 kWh	8 Years

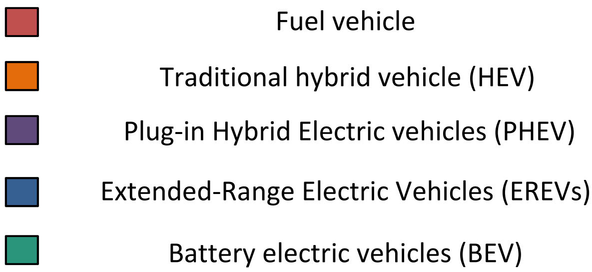
Source: Own creation using complementary data from social media Weblog.SL, 2018.

As we can observe, a mid-size medium of mid-range model like Renault ZOE ZE40 R90 / R110 or Tesla Model 3 are available for a similar price than mid-size medium of mid-range traditional vehicle. Furthermore, battery prices are decreasing very fast year per year and as a result Electrical Vehicle prices are decreasing too proportionally. As a conclusion, in not very far future EVs will cost the same price than a traditional vehicle.

Following in Figure 1 we can observe the engine differences between traditional, HEV, PHEV, EREV and EV vehicles and the engine behaviour.

Figure 1. Comparison of power source schema between different types of vehicles.





Source: S. Magnusson, Wellington, NZ. 5 March 2018.

3.2 Electric vehicle charging technology

Charging infrastructure, whether at home, at work or at public locations, is indispensable for operating EVs. Analysis looking at early EV market developments shows that the availability of chargers emerged as one of the key factors for contributing to the market penetration of the EVs. As electric vehicle charging technology continues to advance, several standards and guidelines have become widely accepted across the industry. To provide a technical background for the following analysis and policy discussion, this section gives a brief overview of charging infrastructure technology, standards, and terminology.

3.2.1 Standards and types of chargers

Charging electric vehicles requires the use of cables, connectors and communication protocols between the vehicles and the EVSE, as well as the EVSE-grid communication. According to IEA (2017) the EVSE suitable for electric cars has three main characteristics:

- **Level**, describing the power output of an EVSE outlet.
- **Type**, referring to the socket and connector being used for charging.
- **Mode**, which describes the communication protocol between the vehicle and the charger.

To provide a quality service for the electric vehicle owners, and to avoid many different types of chargers international standardisation bodies and other associations define these characteristics through standards. Standards may focus on just one of the characteristics or a combination of them. Key standardisation entities involved in the development of these standards include the international Organization for Standardization (ISO); the International Electrotechnical Commission (IEC); the Society of Automotive Engineers (SAE); of the United States; and the standardization Administration of China (SAC) (IEA, 2017). All of them working together to supervise and control the maximum uniformity of type-chargers to avoid the electric vehicle drivers the incompatibility deal in the charging point search.

About the charging technology creators, CHAdeMO, an association of vehicle manufacturers and utilities, also became active in this area in 2009 through the development of a DC quick-charging standard, which was started in Japan and uses a specific type of connector and communication protocol. In 2016, the association announced an amendment to the current protocol, enabling charging up to 150 kW and the development of technical analyses for fast chargers with a higher power rating (350 kW) (CHAdeMO, 2016). Currently, several mass-produced electric cars are equipped with connecting devices enabling the use of CHAdeMO chargers and adaptors are available for most models using different connectors. CharIN is a similar association with a broader scope in terms of membership and representation across the automotive sector. It was established in 2015 with the aim of promoting a global charging standard and now promotes the combined charging system (CCS) and the combo connectors used in Europe and the United States, suggesting a vision for future developments. This approach enables fast charging at 200 kW and developments are now targeting 350 kW (CharIN, 2017a).

In addition to these standard-setting bodies and associations, Tesla has been using its own standard to support all levels and modes of charging through the same connector type. The exception is now Europe, where Tesla needs to comply with the mandate regarding interoperability objectives to use specific standards for sockets and connectors for normal (Level 2) and high-power (Level 3) recharging points. In 2016, Tesla also became a member of CharIN.

In the following table different types of charging technologies are provided in function of the Level, Current, Power, Country, where to find them and approximate charging time.

Table 6. Overview of the level, Current, Power, Place and Charging time of EVSE used in Europe and Japan.

Classification	*Level*	*Current*	*Power*	*Type*		*Place*	*Charging time*
				Europe	**Japan**		
User charger	Level 1	AC	<= 3.7kW	Devices installed in private households, the primary purpose of which is not recharging electric vehicles (Shuko)		Home	<8h
Slow chargers	Level 2	AC	>3.7 kW	IEC 62196 Type 2	SAE J1772 Type 1	Home, work place and public	3-6h
	Level 2	AC	<=22kW	Tesla connector			
Fast chargers	Level 3	AC, triphasic	>22Kw and <= 43.5kW	IEC 62196 Type 2		Public, primarily intercity	<30 min
	Level 3	DC	Currently <200kW	CCS Combo 2 Connector (IEC 62196 Type 2 & DC	CHAdeMO		
	Level 3	DC	Currently <150kW	Tesla and CHAdeMO connectors			

Source: IEA, International Energy Agency. 2017. "Global EV Outlook 2017: Two Million and Counting." *IEA Publications* 1–71.
Note: DC: Direct current, AC: Alternative current, kW: Kilowatt (1000 joules / s)

According to (Hall and Lutsey, 2017), the charging System can also be categorized by "mode," which specifies the type of electric and communications connection between the vehicle and the charging infrastructure. Mode 1 consists of 120 or 240 V charging up to 16 amperes (A) on a shared circuit without safety protocols. Mode 2 consists of 120 or 240 V charging up to 32 A from a standard outlet, on a shared or dedicated circuit, with safety protocols including grounding detection, overcurrent protection, temperature limits, and a pilot data line. Mode 3 allows 240 V charging at any amperage on a wired-in charging station on a dedicated circuit, with the same safety protocols as Mode 2 and an active communication line with the vehicle. This enables smart charging, the coordination of charging according to utility needs, fleet schedules, or renewable energy availability. Finally, Mode 4 is defined as DC fast charging on a 400 V, wired-in connection, and requires more advanced safety and communications protocols.

In function of which mode can we use, we can increase the power of the charger and reduce the charging time but increasing the energy used and in public chargers increase the price of charging.

Talking about Table 6 according to (Hall and Lutsey, 2017) depending on region and speed of charging, the type of plug and socket used for charging electric vehicles may vary. Although these plug types are generally well-defined and each works well for its specific application, the variety of standards may lead to confusion among drivers and hesitation from industry.

In Japan, most electric vehicles use the SAE J1772 connector, which contains five pins and a mechanical lock. In Europe, Level 2 charging uses the Type 2 connector, which has seven pins and takes advantage of the three-phase alternating current grid. In Europe and Asia, Tesla vehicles have a Type 2 plug.

In Figure 2,3 and 4,5 we can see the most used connectors in AC and DC respectively in function of the country and mark.

Figure 2	***Figure 3***
Type: Type 2 IEC 62196 **Country**: Europe, Level 2 	**Type:** SAE J1772 **Country:** Japan, Level 2 
Source: EV Connectors. 2013. "Electric Vehicle Charging Products & Connectors."	

For DC fast charging, connector types vary by automaker in addition to region, with the most common connectors shown in Figures 1,2,3,4. CHAdeMO was created and promoted by Nissan and Mitsubishi in. This type is still used on electric vehicles produced by Nissan, Mitsubishi, Kia, Citroën, and Peugeot. In contrast, several automakers from the United States and Europe have advocated for the Combined Charging System (CCS), which uses the IEC 62196 or AC plugs along with two additional DC pins for fast charging. This standard has now been adopted by BMW, Daimler, Ford, Fiat Chrysler, General Motors, Honda, Hyundai, and Volkswagen. Whereas CCS uses the same receptacle on the car as a Level 2 charger, CHAdeMO requires a separate port. As in the case of Level 2 charging, Tesla uses its proprietary plug for its DC Supercharger stations, although the company also makes Tesla-to-CHAdeMO adapters.

Figure 4	***Figure 5***
Type: CCS **Brand**s: BMW, Daimler, Ford, Fiat Chrysler General Motors, Honda, Hyundai, Volkswagen **Countr**y: Europe, Level 3	**Type:** CHAdeMO Brands: Nissan, Mitsubishi, Kia, Citroën, Peugeot **Country:** Japan, Level 3
	
Source: EV Connectors. 2013. "Electric Vehicle Charging Products & Connectors."	

Basically, the general idea is that the whole charging system has three parts, first, the EVSE which provides the type of socket and Power (Kilowatt), second, the transmission between the EVSE and the car, which is linked to the Mode (Ampers, Voltage, communication and safety protocols and type of connector), and finally the car which is will be connected by a compatible connector and all EVSE and Mode characteristics.

A very important point to keep in mind is the compatibility between the EVSE and the vehicles. If we talk about brands that manufacture electric cars without considering Tesla, these are compatible as long as the connector fits with the type of vehicle waiting connector that has the vehicle and limit the power to which we charge depending on the capabilities of our vehicle. On the other hand, it is important to highlight the company Tesla, which has its own chargers and present certain exclusivity when it comes to being used. Tesla has a type of charger with a type of connector that fits Type 2 IEC 62196, however in the "Superchargers" that uses a DC type of current to allow direct charge of higher powers and this is not compatible with a current type AC, so it would not work if we connect an electric vehicle that is not Tesla in a Tesla charger, although the shape of the connector is the same. Next the manufacturer Tesla has created adapters of Tesla to CHAdeMO so that their vehicles can charge in the CHAdeMO chargers without any problem and have more charging points at your hand.

4. Norway E.V analysis.

Norway is objective of this study because is the country with the highest establishment of electric vehicle that has been developed until nowadays. Norway, at the date of March 31, 2018, has a percentage of PEV (M1) of 7,45% over to the total passenger cars. This percentage is increasing very quickly. As we will see in the next points, this process is due to the incentives in different disciplines related to the electric vehicle that these government has introduced in the country's policy in order to encourage users to make the change from the traditional vehicle to EV. Norway is also a country with 95% electricity generation coming from hydroelectric plants, 2,3% created from thermal energy plants and 1,4% from wind energy plants with a total of electrical energy created from renewable energy of 98,7%.

The breakthrough in terms of electric vehicles' establishment is perfect as a benchmark for comparison with other countries and so, draw conclusions to increase the EV establishment in these countries. In addition, the parliament has been targeted for 2025. The new owners of vehicles and light-duty vehicles must be in 100% vehicles with zero emissions (ZEV). This puts Norway on an ambitious course towards a zero-emission transport sector and an increasingly aggressive step of introducing ZEVS (Stuttgart, Germany, 2017).

4.1 Norway status

4.1.1 Norway general data

Norway, officially the **Kingdom of Norway**, is a sovereign state and unitary monarchy of the North Europe whose territory comprises the western portion of the Scandinavian Peninsula plus the remote island of Jan Mayen and the archipelago of Svalbard. In figure 2 the location of Norway in Europe is shown.

Figure 6. Location of Norway in Europe

Source: Google 2018, INEGI, ORION-ME

In EV establishment comparison with other countries demographic, geographic, economic and transportation data has an important role. In table 7 most important data of Norway is shown.

Table 7. Demographic, geographic, economic and EV transportation Norway data.

Demographic and geographic	
Name	Norway
Capital	Oslo
Population	5.198.425
Total land area (km2)	323.802 km^2
Density population	16 pop/km^2
Residents in urban settlements	4.229.849 (81,13%)
Residents in rural settlements	968.576 (18,87%)
Area of urban settlement (km^2) (>50.000)	2 172,50 km^2 (0,67%)
Rate of residents in urban settlements	1 947 pop/km2
Economy	
Gross domestic Product (in billion EUR)	€ 513,66
Gross Domestic Product Capita (in EUR)	€ 98.895
Transportation and EV	
Highway (km)	194 km
Passenger cars (M1)	2.719.395
Cars per capita	0,52
Electric Plug-in Passenger cars stock(PEV) (M1)	135.552 (7,45%)

Note: *M1: Vehicles used for carriage of passengers, comprising not more than eight seats in addition to the driver's = 9.*

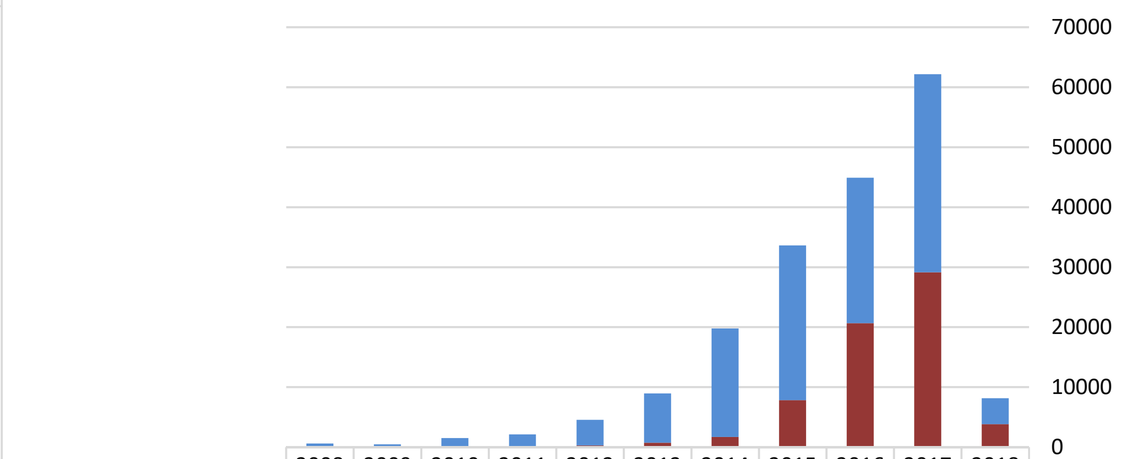
N1: Vehicles used for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes. (Pick-up Truck, Van)

Source: Own creation using data from; European Alternative Fuels Observatory and Statistics Norway Web.

4.1.2 Norway EVs statistics

Norway is the country with the highest percentage of EVs in the world today, 2018. This is due to the sharp increase in EV stock that has been very pronounced in recent years due to the combination of public charging stations establishment and the set of facilities that has been given to the user, to popularise the electric vehicle. The main objective is to make the electric vehicle much more attractive than traditional vehicle. Due to Norwegian Government support, Norway has a market share PEVs, of 41.95%. Figure 20-21 shows the evolution of both EV and PHEV vehicles from 2008 to 2018.

Graphic 17-18. Evolution of the stock of EV and PHEV vehicles in Norway from 2008-2018. Units: New registrations EVs (M1) (17)- PEV market share (M1) registrations (18)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sales number (EV)	489	394	1329	2010	4273	8232	18098	25792	24224	33015	4324
Sales number (PHEV)	110	61	174	96	263	716	1680	7819	20664	29145	3814

Note: *M1: Vehicles used for carriage of passengers, comprising not more than eight seats in addition to the driver's = 9.*

Data source: European Alternative Fuels and Observatory Web, 2018.

As we can see in graphics 17-18, growing of plug-in electric vehicles (PEVs) started a few years ago in Norway. According to European Fuels and Observatory, first noticed EV registrations increase were in 2010 and first important PHEV registrations increase was in 2013.

From 2010 to 2018 the total number of PHEV new registrations has been 45190 and total number of EV new registrations 90362. Both types of plug-in electric vehicle together represent the approx. 5% of total passenger cars in Norway in 2018.

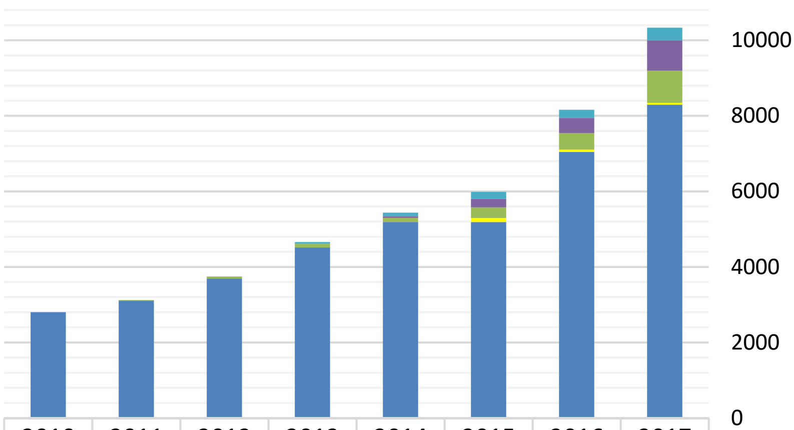
In EV case, the change of market share was 2 years longer because of the earlier beginning in 2010. From 2010 to 2017 the EV market share grew up to 20,82% of total passenger cars in Norway. In four years, from 2013 to 2017 a huge increase of EV market share took place in Norway, from 5,79% in 2014 to 20,82% in 2017.

About the year market share of passenger cars, a rapid increase was suffered too. In Plug-in hybrid electric vehicles (PHEV) from 2012 to 2017 market share grew up to 18,37% of total passenger cars sold per year. Most important increase on NPHEV market share was from 2014 to 2017, from 1,17% market share in 2014 to 18,37% in 2017.

Nowadays, in 2018, market share PEVs of passenger cars keep increasing, PHEV's market share has increased 1,29% percentage points regarding to 2017. In EV case, market share has increased 1,47% percentage points regarding to 2017.

The evolution of charging points in public spaces is also very important to guaranty a successful establishment of the electric vehicles. In the following graph, it is visible the number and type of charging points in Norway from 2010 to 2017.

Graphic 19. Evolution of public charging points from 2010 to 2017 in Norway. Units: Number of charging positions.



	2010	2011	2012	2013	2014	2015	2016	2017
Tesla SC	0	0	0	44	92	190	217	338
CCS	0	0	0	4	49	224	399	803
ChaDeMo	0	18	58	96	108	284	436	852
Type-2AC	0	0	0	0	0	104	65	48
Normal charge (<=22kW)	2800	3105	3688	4511	5185	5185	7040	8292

Data source: European Alternative Fuels and Observatory Web.

Looking at graphic 22, The growth patterns of the normal and fast charging stations have increased considerably in parallel with the augment stock of electric vehicles. Currently in Norway there is a number of 19,6 PEV for each public charging stations. The next sections of this study, gather information about all this. On one side, analyse how the Norwegian government supports the charging stations infrastructure, on the other side, the incentives and legislation used to motivate the future buyers of electric vehicles.

4.2 Evolution of measures to increase E.V establishment

In the evolution of the establishment of electric vehicles there are two major factors that guide growth, and those that is needed to work in order to achieve a good result. The first, and the primary objective, the number of electric vehicles in the country and, the second and not less important to achieve the first, number of fast and normal charging stations available for the fleet of vehicles. It will be studied the measures that Norway has been for all the factors right now.

4.2.1 Increasing number of EVSE measures

The number of fast and normal charging stations is fundamental for the proper development of the electric vehicle establishment. Without a safety charging net, EV owners can only from the charging place where the vehicle would be charged up to a maximum of the autonomy of the vehicle in case of being able to charge the vehicle at its destination, or if this is not the case, a maximum of half the autonomy of the vehicle to guaranty the way back. This effect generates a constant concern of the owner during the trip, having to program suspensions with great care so as not to run out of battery. The role of implementing in the entire country fast charging stations is responsibility of government and his support is important to the "business" of this kind of electric vehicle. In this part of the chapter, measures to increase the number of charging stations in Norway will be studied.

4.2.1.1 Incentives for EVSE deployment

Norway policy measures to incentive EVSE deployment started in 2010 being one of the first movers in the Nordic region to support EVSE deployment.

The national government's main instrument to realise the EVSE deployment is Enova enterprise, established in 2001 is owned by the Ministry of Climate and Environment and contributes to reduced greenhouse gas emissions, development of energy and climate technology and a strengthened security of supply in Norway. Enova is financed through government funding in addition to NOK 0.01/kWh (0.001€/kwh) tax on electricity to consumers. Its 2017 founds is around NOK2.5 billion (0.26€ billion) (IEA 2017)

In 2010, Enova's (formerly Transnova in 2010) deployment of EVSE outlets started through a NOK 50 million (5.3€ million) and with the objective to create a support programme that subsidised normal charging points up to NOK 30000 (3160€) per charging point. The total support amounted and the scheme resulted in around 1800 Schuko-points (household sockets) spread all over the country. Many of these points can still be used, but several are also taken out of service due to high maintenance costs.

In 2013 Transnova supported fast charging infrastructure with NOK 6 million (640000 €), both programmes supported the 100% of the installation costs of the fast charging stations, specifically, the support was 100% of the investment costs with an upwards limit of 300000 NOK for each triple standard charger, operation costs were not included according to Enova (2017).

Nowadays, Enova provides up to 40% of the eligible costs for municipalities without chargers in Norway.

Furthermore, the support for fast charging establishment corridors in Norway has been prioritised in the recent years. Again Enova, created an incentive programme (10,5 million NOK, 1,1 million €) scheme to deploy a publicly available fast charger at least every 50 km on the highway network (about 7500km) with a maximum distance of 1 km from the highway. To reduce the risk for charging stations being out of order and reduce charging ques all locations must have at least two multi standard fast chargers (CHAdeMO and CCS) in addition to two 22Kw Type 2 points (Lorentzen et al., 2017). The construction of the charging stations started in 2015 and almost all highways were served by the end of 2017.

This measure affects a lot in interurban travels autonomy customer safety and is one of the main reasons of the Electric plug-ins vehicles increase from 22.3% to 39,2% share of total number vehicles in Norway. However, even with 100% funding of the installations, no companies have bid on Enova's fourth tender round to build charging stations in the far north of the country and the Lofoten Islands (IEA 2017).

According to the data shown in graphic 22 we also can see a growing trend that fast charging operators are building charging stations without public support, according to (Lorentzen et al., 2017) Norway is in the beginning of functioning market where governmental support is no longer needed, and the development of charging stations is based on pure commercial decisions, a crucial fact for the further development of FCS.

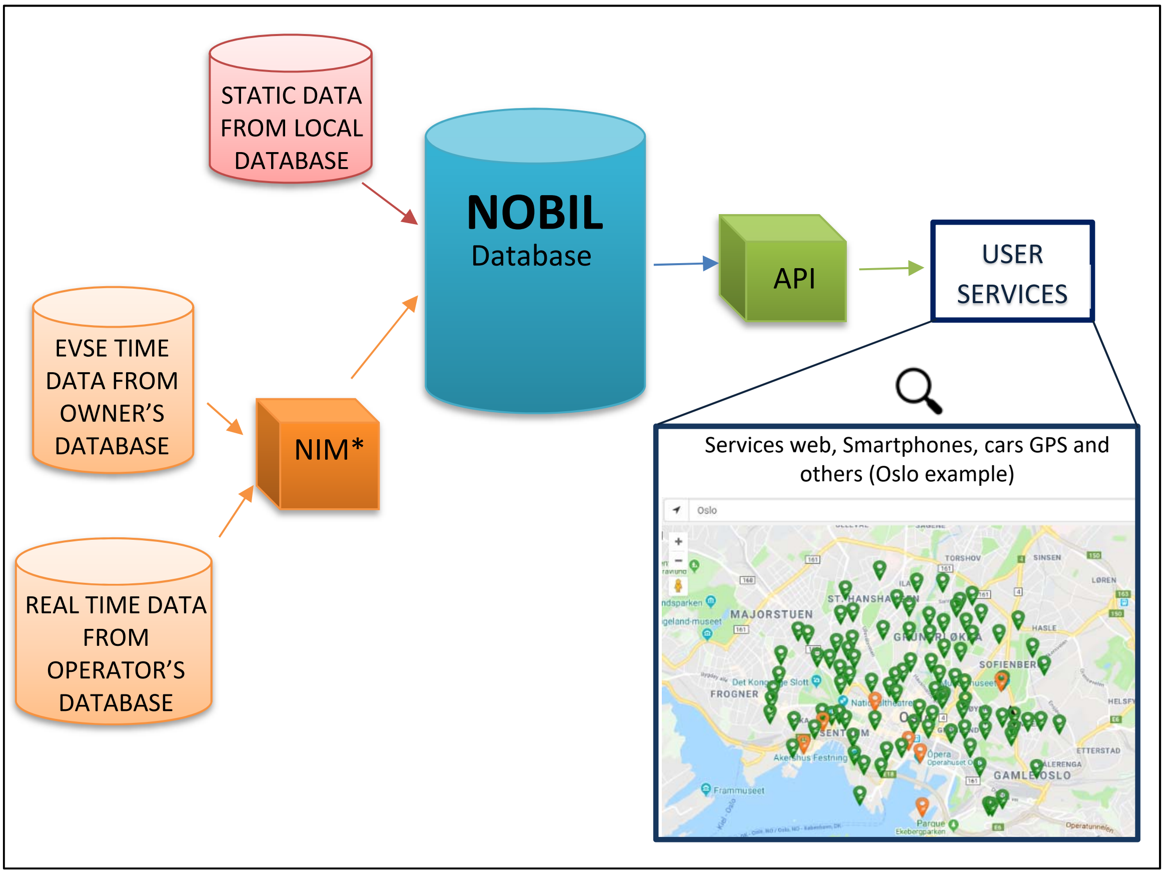
4.2.1.2 National database for EVSE

While the national charging stations were being built from the collaboration of the Norwegian government with Enova in 2009-2010, the experts thought how the benefit of each of them could be maximized. They realized that if the location and characteristics of each charging stations were communicated to the citizen, this greatly optimized the interaction between the EV-users and the electric charge network they were building. Then, the answer was to collect all the information in a database and to distribute it publicly with the aim of increasing the knowledge of the availability and characteristics of the network of charging stations for electric vehicles. So, the governmental institution Enova and the Association of electric vehicles of Norway decided to make the database being born NOBIL.

NOBIL is developed and maintained by the Norwegian Electric Vehicle Association but it is owned and financed by Enova. His functionality is based on the storage of the information of the users of EV, the owners of electric charging stations, operators and other contributors and communication through third parties. NOBIL isn't an instrument for operations, only a database. This doesn't interfere in the businesses of the operators and owners of the charging stations, leaving a free market for the uses that users may have and it was created with free software tools. The platform include detailed information about charging stations, receive and distribute this in real time. Thanks to NOBIL is possible to find publicly this kind of info like accessibility for the users, connectors type, charging capacity, coordinates of the charging station and photographs. The data set of the database has the objective of expanding continuously as new charging stations are built. EV-users services use these information from NOBIL in his everyday life from mobile applications or within the GPS navigation system of your electric vehicle.

The data from NOBIL are free available from the API (application programming interface), it is only necessary to register as an API user and accept the terms of conditions. In response you get a password, API-key, for access. You can download all the information you want from there. In the following figure, we can see the scheme of the previous operation.

Figure 7. Scheme on the context of the NOBIL database of the Government of Norway.



Source: Own creation using Kvisle, Hans Håvard. 2012. "The Norwegian Charging Station Database for Electromobility (NOBIL)." *World Electric Vehicle Journal* 5(3):702–7.

Note: NIM is a function facilitating interactivity between the database NOBIL and communicative charging stations or back-end systems. The infrastructure pushes data over http according to a defined XML which is attempted standardized to other open protocols. NIM is a gatekeeper, only updating the database with significant events

4.2.2 Evolution of measures to increase E.V stock

A so much important point when it comes to getting citizens to change the traditional vehicle to electric vehicles is the legal and regulatory policies that the government establishes over electric vehicles. The main points in which it is act are:

- Price incentives and the moment when you are deciding to deal with the initial investment that involves the price of an electric vehicle. These are called fiscal incentives and subsidies for reduction of purchase cost.
- Direct subsidies to reduce the usage costs and range challenges.
- Reduction of the time costs and giving relative advantages.

Table X shows a little summary about national incentives, policies and initiatives in Norway since 1990.

Table 8. National incentives and policies in Norway.

Incentives	Year
Fiscal incentives and subsidies reduction of purchase price	
Exemption from registration tax	1990/1996
Reduced annual vehicle license fee	1996/2004
Reduce company car tax	2000
Exemption from VAT	2000
Ownership tax exemption	-
Direct subsidies to users reducing usage costs and range challenges	
Free toll roads	1997
Exemption from paying car ferry fees	2009
Reduction of time costs and giving relative advantages	
Access to bus lanes	2003/2005
Free parking	1999
Free charging	-

Source: Kolhe, Mohan Lal and T. P. Chathuri Madusha. 2017. *The Scenario of Electric Vehicles in Norway*. Elsevier Inc.

4.2.2.1 Fiscal incentives reduction of purchase price

Norway is a country concerned in incentives since the beginnings, specifically the first measure was in 1990 with what it excluded purchase and import taxes when someone would decide to acquire an electric vehicle.

4.2.2.1.1 Exemption from registration tax (1990/1996)

Registration tax based on vehicle weight, engine power, nitrogen oxide emissions and CO_2 emissions have a value in Norway of approximately NOK 95000 (10,000€) for diesel and gasoline cars. The combination between the high cost of the purchase and the exemption tax, temporarily since 1990 and permanently applied in 1996, in the moment when someone think in purchase is what do that the unit price of EV is become in a competitive reason to acquire it in front of traditional vehicles. The PHEVs are authorized to obtain a 26% deduction in the purchase tax component due to the low emissions generated by them.

4.2.2.1.2 Exemption from VAT (2001)

In Norway, there is the Value Added Tax (VAT) in all purchased beings. An additional 25% is added to all the products and services offered in Norway. For traditional vehicles, tax is in addition to the sale price while EVs have been exempted from the VAT payment since 2001. In the case of PHEVs, they don't have the privilege as the EV in relation to VAT. They have to pay the total payment of the tax as a traditional vehicle. Further, the exemption from VAT is being reconsidered to be replaced by a subsidy scheme that will initially be at the level of the value of VAT exemption.

4.2.2.1.3 Exemption from Ownership tax

Norway government has introduced the Ownership tax exemption to their fiscal incentives to promote the establishment of electric vehicles.

4.2.2.1.3 Reduced annual vehicle license fee (1996/2004)

The annual driver's tax is applied on three rates of all private vehicles registered in the vehicle register in Norway. This is valid throughout the year. The reduction of this annual tax is approximately 3320 NOK (350€) compared to the Electric Vehicle 470 NOK (50€) and the traditional vehicle 3795 NOK (400€).

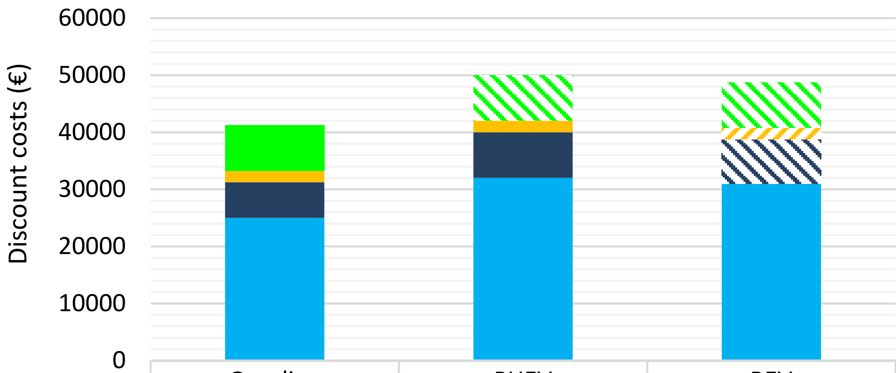
4.2.2.1.4 Reduced company car tax (2000)

The vehicles whose property is the company can also be used for private use. However, the user must pay a little tax for this benefit. The reduction of company vehicle tax was introduced in the year 2000. The tax on the vehicle what is used by Enterprise like a private vehicle, in the case of electric vehicle, is 60% more lower than the traditional vehicle. In the private use ICE/PEV comparation price this tax is not included.

4.2.2.1.5 PEV/ICE private passenger car purchase price comparison in 2018

Finally, graphic 20 summarizes the tax incentives of medium size different types of cars (Gasoline, PHEV and EV) In Norway. The exemption from the registration tax is generally the most important fiscal incentive, followed by the VAT exemption for EVs- While PHEVs are no exempt from the registration tax, they still incur lower registration taxes than conventional vehicles due to lower CO_2 emission values. The favourable vehicle taxes EVs generally imply the cost of purchasing and EV for private use is lower than a comparable conventional car.

Graphic 20. Purchase direct incentives comparison for private passenger cars with different engine vehicles.



	Gasoline	PHEV	BEV
Registration tax	8000	0	0
Registration tax reduction	0	8000	8000
Ownership tax reduction	0	0	2000
Ownership tax	2000	2000	0
VAT	6250	8000	0
VAT reduction	0	0	7750
Price	25000	32000	31000

Medium size car

Data source: Tietge, Uwe, Peter Mock, Nic Lutsey, and Alex Campestrini. 2016. "Comparison of Leading Electric Vehicle Policy and Deployment in Europe." *White Paper* (May):1–81.

4.2.2.1.6 PEV/ICE private passenger car purchase price and usage cost comparison in 2018.

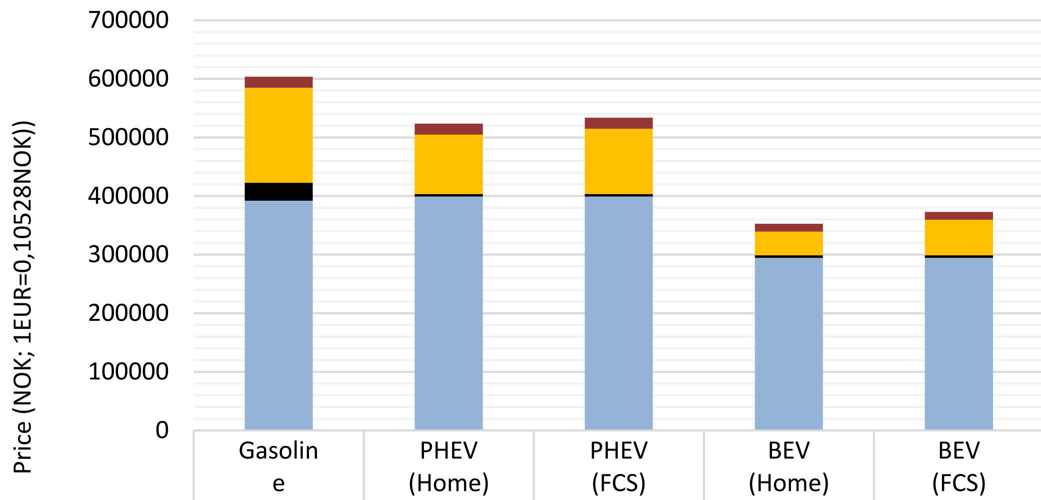
For this calculation, we have assumed a 5,0 L/100km consumption of gasoline for the gasoline vehicle and an average price for the gasoline in Norway for the consumer (with taxes) of 16,21 NOK/L (1,70 €/L).

For the plug-in hybrid car (PHEV gasoline have assumed half kilometres with gasoline and half with electricity. We have assumed consumption of gasoline of 3.4 L/100km and 14.4 kWh/100km of electricity to Renault (2017). In the charging at home calculation electric price will be 1,52 NOK/kWh (0,16 €/kWh). On the other hand, in the calculation that we assume the vehicle always charges using fast charging stations. The charging price depends of FCS’s owner, in this case we have used 0,24€/kWh, the price of the Superchargers of Tesla. This price is very competitive and is not the highest one that can be found in Fast charging stations of other companies (Tesla (2017)), objectively, we must take in consideration the optimistic fast charging station price. Finally, gasoline price will be 16,21 NOK/L (1,70 €/L), as in the gasoline case.

For the electric car (EV) we have assumed a 13 kWh/100 consumption. Electricity prices for charging at home case and Fast charging station case are the same than PHEV’s prices.

About the maintenance cost according to the Renault (2017) article, the price of the maintenance cost for 200.000km mid-size electric vehicle is about 30% less than the Gasoline vehicle. The maintenance cost of a medium size Gasoline vehicle (Renault CLIO IV) without any reparation costs is 19.000NOK (2000€), so, the maintenance cost of Electric vehicle is 13.300 NOK (1400€) (Renault ZOE). Graphic 36 Show the comparison between the Gasoline vehicle, PHEV and EV. The purchase cost is the result of the Graphic 20.

Graphic 21. Comparison between the Gasoline vehicle, PHEV and EV purchase and usage costs.
Units: EUR



	Gasoline	PHEV (Home)	PHEV (FCS)	BEV (Home)	BEV (FCS)
Maintenance	18997	18997	18997	13298	13298
Usage costs (200,000km / 10 years)	162100	101263	111369	40426	60638
Annual fee (10 years, Type 4)	30600	4350	4350	4350	4350
Purchase cost (including taxes exemptions)	391812	398936	398936	294453	294453

Midel size vehicle

Data source: Own creation using data from Purchase direct incentives comparison for private passenger cars with different engine vehicles and Eurostat statistics Web.

In addition, the prices that we visualize in the previous graphic are not the final prices of the owner of a EV. We must bear in mind, that these costs are pure costs of using the electric vehicle while EV, will also be able to take advantage of economic incentives such as, free toll roads, exemption from paying car ferry fees, free parking and free charging. However, these expenses will depend greatly on the type of use made by the owner of the electric vehicle and are very changeable depending on the routes and areas where the EV is driven.

4.2.2.2 Direct subsidies to users reducing usage costs and range challenges

4.2.2.2.1 Free toll roads (1997)

In 1997, electric vehicles have the benefit of not pay road taxes in Norway. In other words, they don't have to pay tolls or other controls. These taxes are used to increase public transportation and expand capacity of roads. Although, this action of the government is a considerable benefit for owners of electric vehicles, the effect of excluding electric vehicles from paying highway taxes has had a considerable impact on the income of road tax companies.

4.2.2.2.2 Exemption from paying car ferry fees (2009)

EVs don't have to pay any traffic tax on ferries since 2009. Passengers responsible for the vehicle, however, must pay for the travel ticket. This means that this incentive to people to use ferries often in Norway. It is an analogy of road tax exemption for people who use roads, but in this case, rather transport their vehicle using ferry and driving it in their travel destination.

4.2.2.3 Reduction of time costs and giving relative advantages

4.2.2.3.1 Access to bus lanes (2003)

Since 2003, electric vehicles were allowed to use some bus rail as a test mode in some streets, specifically in Oslo, but until 2005 it become as a permanent license. The access of bus lanes affected so much in purchase of electric vehicles in roads like Asker's, Oslo because the citizens saw an opportunity not to suffer traffic collapse. Free access on public transport lines in the large cities of Norway is very efficient and that saves driving time which is analogous of an economic saving.

4.2.2.3.2 Free public parking with free charging (1999)

Since 1999, electric vehicles have a free access to public car parks. In many public car parks in Norway, the opportunity of free charging is available. In 2013, PHEVs also had access to the free charging points.

The free parking with the possibility of free charge is very attractive and has a lot of call to action for electric vehicles users. In addition, it is a save of time and money because they obtain a space where they can park and charge at the same time without no headaches or worries. Increasingly, the time used to find a parking in large cities can be 30min-1h, so for large cities EV users, this incentive is very appreciated.

4.3 Norway Customers habits and tendencies

4.3.1 Charging behaviour

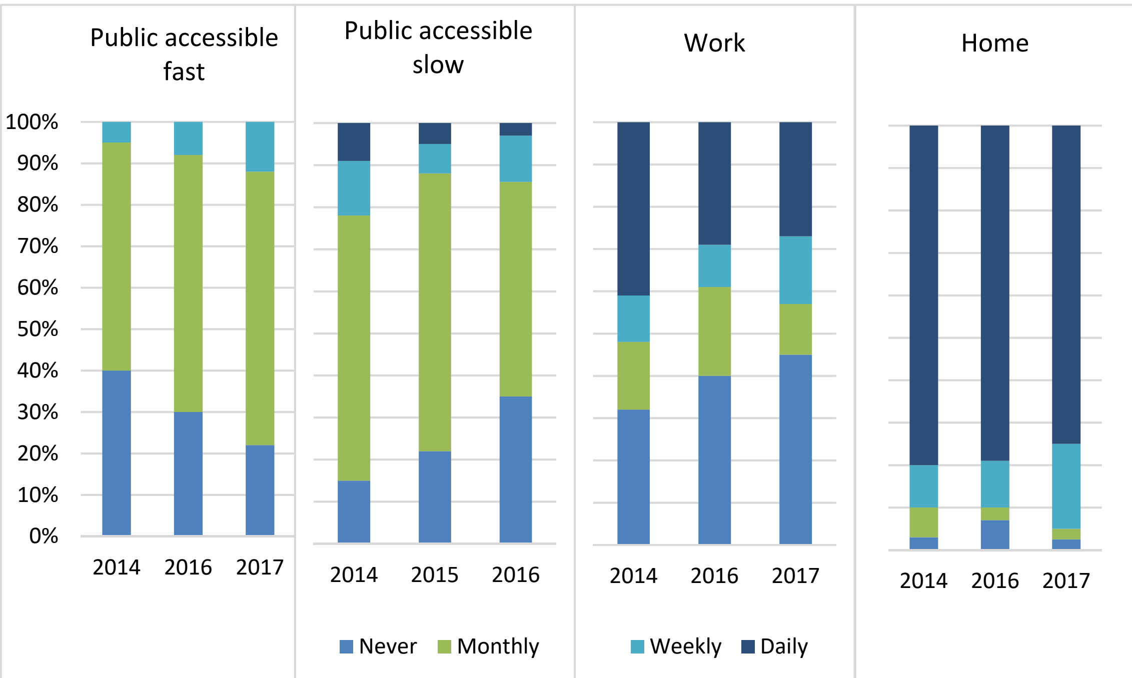
In this part, we can analyse EVSE types, which ones are most used in in Norway. IEA (International Energy Agency) share, along with sources of information about services EV and PHEV owners, that the electric vehicles drivers charges their vehicles when they are at home or sometimes in the hours of job with a slow charger. A 63% home charger, are ordinary chargers without additional functionalities whilst a 19% of that are install for wall box with 3,7 Kilowatt (Kw), a 12% between 7 and 22Kw and only 3% is of Tesla brand (Norsk Elbilforenung, 2017). This preference for the home chargers is because of little frequency of long travels with electric vehicles. The majority is used like a practical vehicle - job (92%) or everyday life travels (57%).

Furthermore, a 90% of users who use frequently the home chargers confirm they have no problems and negative experience (Nordic Elbilforening, 2017). The third trend of charging is in public points of slow charger. Fourth option is chargers in services points (commercial and leisure facilities) also called "destination charge" because they are installed in hotels, CCs or restaurants.

Electric vehicles users with a preference of driving 20-40 Km/daily, are the most users of electric home chargers because the vehicle need a reduced energy and as a consequence, a reduced charge time (less than an hour and 30 minutes with a normal slow charge). Fast charging stations are just the favourite option in case of travel long distances. The consumers of this kind of charges have a good experience and a few problems with queues when they are in a station, so, that means that the actual net of fast charging stations could cover the needs of the actual Norwegian electric vehicle network (IEA, 20187)

In Graphic 22 we can see the frequency of charging from electric users by EVSE category in Norway from 2014 to 2017.

Graphic 22. Frequency of charging by EVSE category in Norway, 2014-2017
Units: Percentage (%).



Notes: As the IEA expose: *"The surveys used to develop this graph have wide coverage of electric car owners. However, the 2017 data do not cover the same group of participants as the 2014 and 2016 data. The survey questions also varied slightly over time. Location categories have been harmonised here to: publicly accessible fast (average use in winter and summer period), publicly accessible slow, workplace and home chargers – including garage, carport (open-air parking place). Weighting factors for detached houses and apartment buildings were based on the 2017 distribution. The time categories are harmonised to daily (every day, three-five times per week), weekly (once or twice a week), monthly (less frequent, 1-2 days per month, infrequent) and never"*

Source: IEA, International Energy Agency. 2018. "Nordic EV Outlook 2018."

Compared to 2014 data, fast public chargers are used with a more frequency and less people bet on slow public chargers. This could partly be explained by the improved coverage of fast charging networks. Work charging and home charging have been used less frequently since 2014, possibly reflecting the increase in battery capacity and electric car drive ranges.

Finally, the preference for home and job chargers matches with the fact that users of fast chargers on the street aren't entirely satisfied (Norsk Elbilforening, 2017). In practice, only 4% of electric car owners have experienced an empty battery and less than a quarter experienced a "close call". In addition, electric car owners also saw charging time as the second-largest disadvantage of owning an electric car, following range limitations (Figenbaum, Kolbenstvedt and Elvebakk, 2014). Almost 20% of electric car owners in Norway did not use their electric car on several occasions due to the lack of chargers and more than 10% due to long charging times (Norsk Elbilforening, 2017). This is in line which shows that in Norway the perceived lack of charging infrastructure, either at home or while driving, is the single largest reason why consumers are not considering the purchase of an electric car (Norsk Elbilforening, 2018).

Another survey conducted by the Norwegian EV association, related to the charging behaviour, shows the characteristics and cost habits of the EV users that live either in a Detached house or in an Apartment building. Why? The reason is very important to keep in mind since not all the people have available a normal charger at home. They leave the vehicle always in the street, however there are solutions for this type of proprietary electric vehicles like public chargers. In the following table, we can observe the data survey.

Table 9. Question: *How often do you charge?*

Location	*Frequency*	*Detached housing*	*Apartment buildings*
At home	Daily or weekly	97%	64%
	Monthly or never	3%	36%

At work	Daily or weekly	36%	28%
	Monthly or never	64%	62%
At public charging stations	Daily or weekly	11%	28%
	Monthly or never	89%	72%
At fast charging stations	Daily or weekly	12%	18%
	Monthly or never	88%	82%

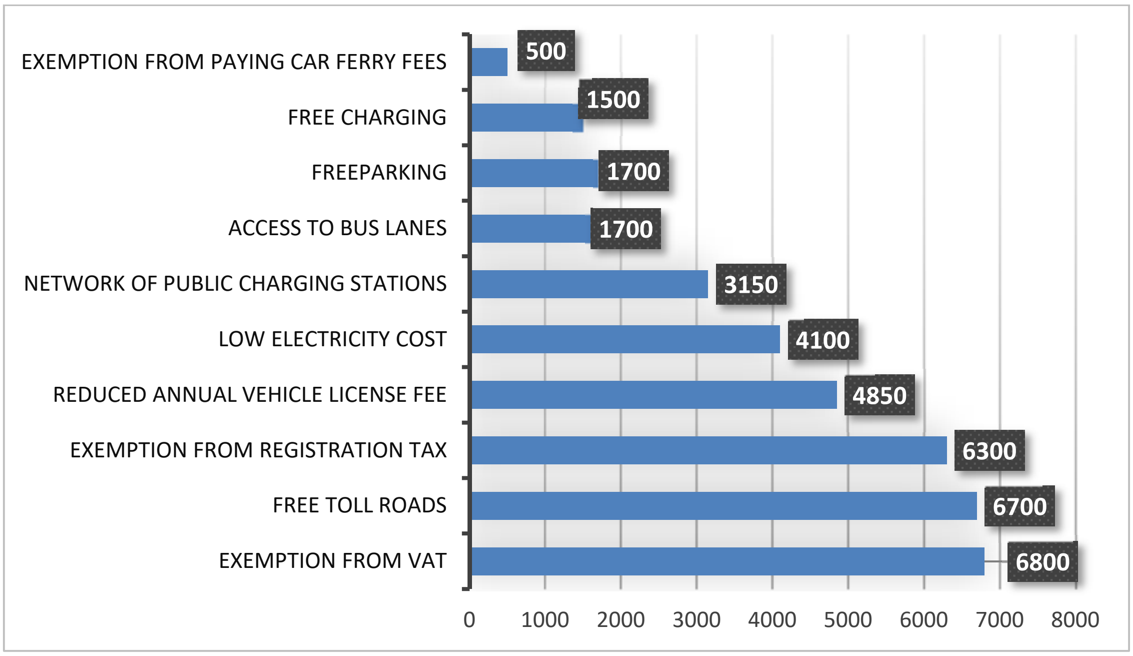
Source: Lorentzen, Erik, Petter Haugneland, Christina Bu, and Espen Hauge. 2017. "Charging Infrastructure Experiences in Norway - the Worlds Most Advanced EV Market." *Evs30* 1–11..

The 97% EV owners who lives in detached housing charge at home daily or weekly, while those living in apartment buildings charge at public charging stations and use fast charging more frequently. We also note that most EV users don't fast charge on a weekly basis. Normal charging while the car is parked is in other words the dominating charging method. However, fast charging is crucial when needed, for instance on longer trips. Fast chargers also function as an important "safety net" for everyday use.

4.3.2 Most important incentives for EV owners

As we have seen in chapters before, Norwegian Government has supported the E.V establishment using policies and incentives to motivate the population to change from ICE vehicle to EVs. So, in this chapter we will analyse the most important incentives realised by the Norwegian Government for the EV owners. EV owners have been asked to select the three most important EV incentives and in the graphic 25 we can see the result of that survey.

Graphic 23. Most valued EV incentives survey results in Norway.



Data source: Own creation using data from; Lorentzen, Erik, Petter Haugneland, Christina Bu, and Espen Hauge. 2017. "Charging Infrastructure Experiences in Norway - the Worlds Most Advanced EV Market." *Evs30* 1–11.

Charging is obviously a very important concern for EV users. However, the results from the survey also shows that the most valued incentive is the VAT exemption at the time of purchase, followed by other economic incentives like exemption from road tolls and low electricity costs. Access to public charging network is also an important incentive, in general EV Norwegian owners rather paying less at the moment of the vehicle acquisition than the Reduction of time costs and giving relative advantages.

4.4 Norway conclusions

Norway is a country with a good sense of taking advantage of its resources. Norway electricity generation is 98% coming from renewable energies. So, the EV and PHEV fleet represents a sustainable and almost totally zero-emissions mobility.

Since 1990, Norway has been introducing incentives to promote and popularise the establishment of EV such as fiscal incentives reduction of purchase price, direct subsidies to users reducing usage costs and range challenges and reduction of time costs and giving relative advantages. Whit these incentives, Norway has reached an EV and PHEV market share of 40% and the it keeps increasing year after year.

Regarding to the charging infrastructure, there is always a debate between the egg and the hen, being these the EV stock who provides the demand to the charging stations and the charging stations. However, the number of EV and PHEV new registrations graphic (21) shows that there is a substantial number of users that would by an EV without an integral fast charging network. These users match with the definition of users owning more than one vehicle living in detached houses. Last elements allow them to use the electric vehicle specific occasions and can recharge it at home. These users are very helpful in the beginning of the popularise procedure of new technology.

Norwegian Government has invested a few amounts of money in the increasing of charging infrastructure (7,5 million EUR). The explanation of the great results with low amount of money is according to the Norwegian Ministry of Transport and Communications in the National Transport Plan (2016) the total ban of gasoline and diesel, production, sales and new registrations in Norway since 2025. Norway will be the first world country to apply this measure, consequently enterprises of private sector such as; gas stations companies, gasoline/diesel car companies or new investors, has seen been obligated or has seen the opportunity to invest in charging stations business. Even if fast charging is essential to avoid "range anxiety" and is a relevant incentive when people is considering buying an EV, domestic charging is still the most important and effective way to charge an EV every day for Norwegian population.

The reason of the high market share of EV and PHEV in Norway is the strong fiscal incentives that Norway offers in the purchase price of the EV, direct subsidies to users reducing usage costs and range challenges and reduction of time costs giving relative advantages. With these incentives, Norwegian Government has reached a balanced price between the EV, PHEV and Gasoline vehicle. As we saw in the comparation purchase price of private passenger car, a mid-size and mid-class EV is 25% cheaper than the Gasoline Vehicle. Fiscal incentives reduce the EV purchase price in 36% which is really valued and appreciated by Norwegian population who want to buy a new EV as we can see in the surveys. Consequently, as we saw in the comparison between the Gasoline vehicle, PHEV and EV purchase and usage costs, the 10 years usage costs added to the purchase price of the EV is 40% lower that the Gasoline vehicle.

Finally, the challenge is real when we see so many people of a lot of cities live in apartments. If we want to move towards a system of no emissions transport. Shared apartment buildings have to be “ready for charging”, in other words, have a basic structure with which each owner could connect, install and pay a charging station in their own parking place. The basic infrastructure has to include a dynamic system of effects distribution if it’s necessary. In new buildings, it’s a must a basic infrastructure for a future population EV 100%. However, in existing buildings it’s an obligation the option that electric vehicles owners install charging stations on request.

5. Japan EV analysis

Japan owns one of the leading electric vehicle market in the world and currently boasts the third largest fleet of electric vehicles, with over 200.000 electric vehicles sold in Japan since 2009, falling just behind the USA and China. The quick uptake of electric vehicles in Japan is largely attributable to the pro-electric vehicle stance taken by the Japanese government since the mid 1990's.

In 2009, the Green Vehicle Purchasing Promotion Measure was introduced, which offered tax deductions and exemptions in order to encourage early adopters to choose electric vehicles over traditional vehicles.

As well as offering incentives to electric vehicle owners, the Japanese government have invested hugely in the development of a charging infrastructure across Japan. In 2013, the Japanese government enlisted the help of Nissan, Honda and Mitsubishi to build a user friendly electric vehicle charging infrastructure. The partnership, Nippon Charge Service, offered financial assistance to businesses offering charging points in key locations across the country. The partnership targeted charging facilities that had high public value, such as commercial facilities, service stations and convenience stores.

The number of electric car charge points in Japan overtake the number of petrol stations in early 2016. In a study conducted in 2016, it was found that there are now over 40,000 private and public charging points in Japan, compared to 34,000 petrol stations.

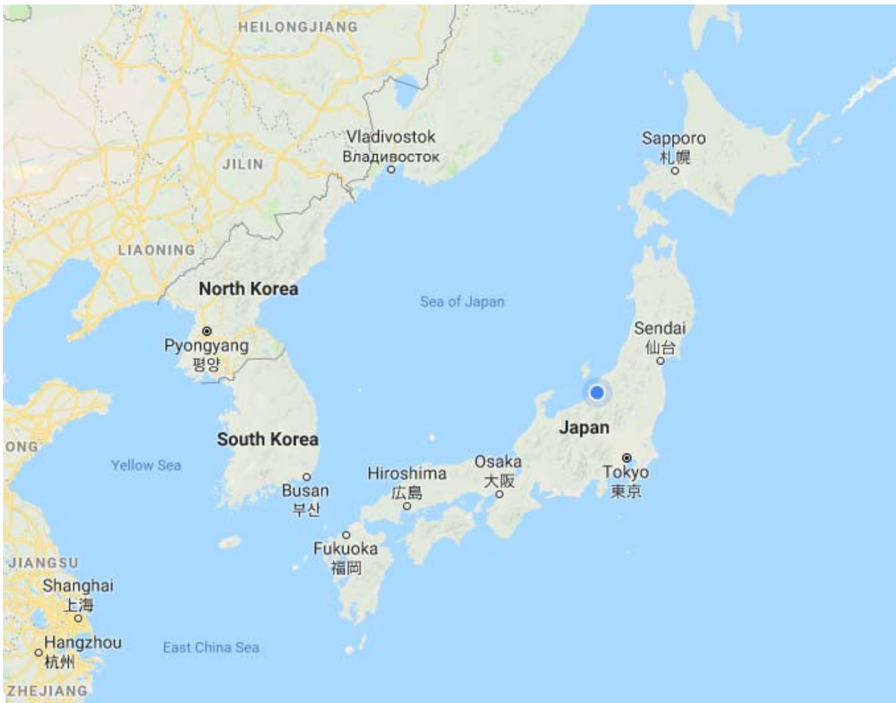
The key to the success of the electric vehicle market in Japan is a committed government and support from the automotive industry and user-friendly infrastructure. For countries looking to become a prominent player in the electric vehicle market, Japan is a shining example.

5.1 Japan status

5.1.1 Japan general data

Japan is a sovereign island nation in East Asia. Located in the Pacific Ocean, it lies off the eastern coast of the Asian mainland and stretches from the Sea of Okhotsk in the north to the East China Sea and China in the southwest.

Figure 8. Location of Japan in Asia



Source: Google Maps 2018

Demographic, geographic, economic and transportation general data is shown in the next table.

Table 10. Japan Demographic, geographic, economic, Transportation and EV data.

Demographic and geographic	
Name	Japan
Capital	Tokyo
Population	126.672.000
Total land area (km2)	378.000 km2
Density population	336/km2
Residents in urban settlements	98.804.160 (78 %)
Residents in rural settlements	27.867.840 (22%)
Area of urban settlement (km²) (>50.000 pop)	47.850km2 (12,7%)
Rate of residents in urban settlements pop/km2	2064,87 pop/km2
Economy	
Gross domestic Product (in billion EUR)	4.802,806
Gross Domestic Product Capita (in EUR)	37,98
Transportation and EV	
Highway (km) (Expressways)	10.021 km
Passenger cars (M1)	68,900,000
Cars per capita	0,54
Electric Plug-in Passenger cars stock(PEV) (M1) (2017)	207.335 (0,3%)

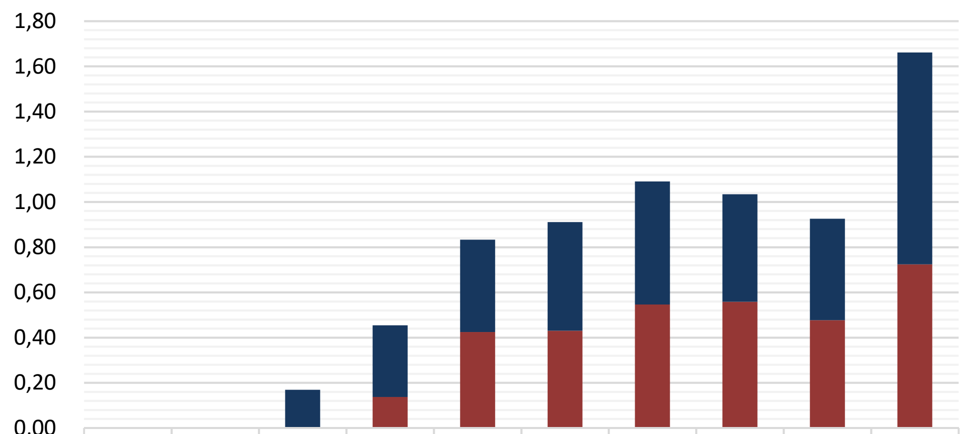
Note: M1: Vehicles used for carriage of passengers, comprising not more than eight seats in addition to the driver's = 9.

Source: Own creation using data from; Statistics Japan Perfecture Comparison (http://stats-japan.com/t/kiji/10786), Next Generation Vehicle Promotion Center (http://www.cev-pc.or.jp)

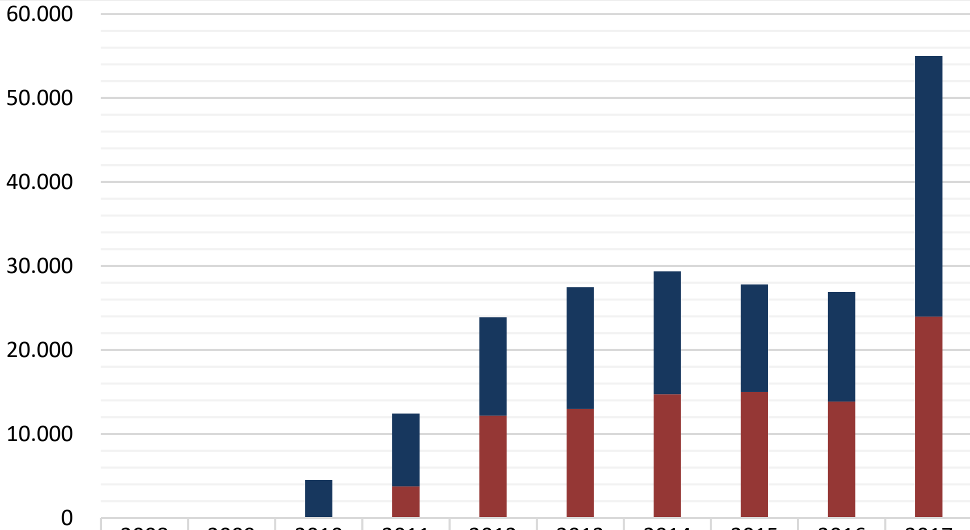
5.1.2 Japan EV statistics

Japan is one of the countries with the highest density population in the world, specifically the density of population in relationship with the total area of Japan is 336 people/km^2. However, most people living in Japan are in the urban settlements (78%), so the urban areas density of people is 2065 people/km^2. This demographic statistic is very important to understand how the EV establishment is evolving with this amount of people living in a few kilometres of terrain because of the consequences in the electric vehicle establishment. The total number of Japanese passenger cars is 69 million and there is a rate of 0,54 cars per capita. Further, the total number of electric plug-in passenger cars is 207.335 what would be a huge number of PEVs but the high number of total car passengers make the relevance of this amount very low (0,3%). In the graphics 50-51 are shown the number of new registrations per year and the rate of EV and PHEV in Japan from 2010 to 2017.

Graphic 24-25. Changes in BEH y PHEV market and stock in Japan from 2008 to 2017. Units: PEV market share (M1) (20)-New registrations EVs (M1) registrations



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Sales rate(EV)	0,00	0,00	0,17	0,32	0,41	0,48	0,54	0,48	0,45	0,94
Sales rate(PHV)	0,00	0,00	0,00	0,14	0,42	0,43	0,55	0,56	0,48	0,72



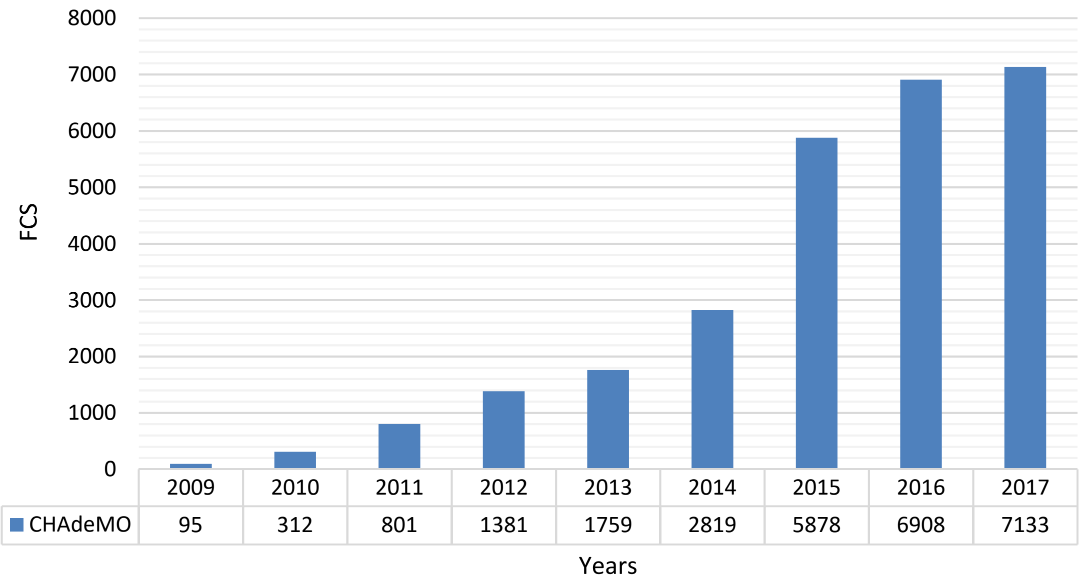
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Sales number(EV)	0	2	4.511	8.674	11.705	14.494	14.649	12.794	13.056	31.035
Sales number(PHV)	0	0	0	3.742	12.178	12.972	14.714	14.997	13.847	23.965

Source: Next Generation Vehicle Promotion Center Web, 2018.

As we can see in the graphics above, the first EV were sold in 2010. Since then, PEV sales have been increasing until 2014, where they represented 1.09% of total passenger vehicle sales. However, from 2014 to 2016 these sales were reduced to 0.93% but in 2017 sales were very high and represent 1.66% of vehicle sales in Japan. This recent increase represents the start of the increase in electric vehicles in the country, which is being carried out with the subsidies and push measures of the electric vehicle. Unfortunately, the share that PEVs represents in Japan is very low, just a 0,3% of the total vehicles are PEVs in 2018.

About fast charging stations in Japan, only CHAdeMO has established fast public charging points. In the Graphic 52 the evolution between 2010 and 2018 of CHAdeMO charging stations have been represented.

Graphic 26. Number and type of public fast charging stations from 2010 to 2017 in Japan.
Units: Number of Fast charging stations.



	2009	2010	2011	2012	2013	2014	2015	2016	2017
CHAdeMO	95	312	801	1381	1759	2819	5878	6908	7133

Source: Number of quick charging station in Japan, Chademo, 2017.

As we can see in the graphic below, Japan has a huge net of Fast Charging Stations with a total number of 7133 fast charging stations around the Country. This is a very important aspect of Electric vehicle establishment in Japan. It reduces the “range anxiety” for long travels. The number of normal charging stations in japan is 33.000 in 2018.

5.2 Japanese measures to increase EV establishment

5.2.1 Improving number of EVSE measures

As charging infrastructure is a precondition for the population to shift to next generation vehicles, charging facilities installation is also subsidised at around half of its cost for Japanese Government. A minimum of eight years ownership is requested if the purchase was subsidised. This next generation vehicle promotion scheme was first (2009) dedicated to quick charging infrastructure, but in 2010, METI started focusing more on normal chargers mostly to promote charging devices in houses or housing buildings (see Figure 8).

5.2.1.1 Incentives for EVSE establishment

In March 2012, METI launched a large-scale project named “Next Generation Vehicle Charging Infrastructure Deployment Promotion Project” using 100 billion JPY (772,2 million EUR) of supplementary budget for Fiscal Year 2012. With the objective of strategic and quick deployment of charging infrastructure, this project has encouraged municipalities and expressway operating organizations nationwide to issue charger deployment plans, which were made public starting in April 2013. This ground-breaking project not only subsidize the cost of chargers but also 2/3 of the installation costs for the municipalities and organizations who intend to install public chargers based on their published charger deployment plan, which shall accelerate the deployment of charging infrastructure along the principal routes nationwide (Chademo, 2013)

In 2015-2016 METI developed a Project for facilitating the development of charging infrastructure of 30.0 billion JPY (231 million €). This is a project for subsidizing the purchase price and installation costs of battery chargers to promote the use of next-generation vehicles.

In 2010, Toyota Motor Corporation, Nissan Motor Co. Ltd., Mitsubishi Motors Corporation, Fuji Heavy Industries Ltd., and Tokyo Electric Power Company, Inc. had formally established “CHAdeMO Association.”. At the time 158 business entities and government bodies including 20 foreign companies from multiple sectors such as automakers, electric utility companies, charger and component manufacturers, charging service providers and others joined the Association. The Association aimed to support the diffusion of electric vehicles, which would contribute to the CO_2 emissions reduction in the transport sector, from the infrastructure side and to take an active role in the standardisation of EV charging protocols.

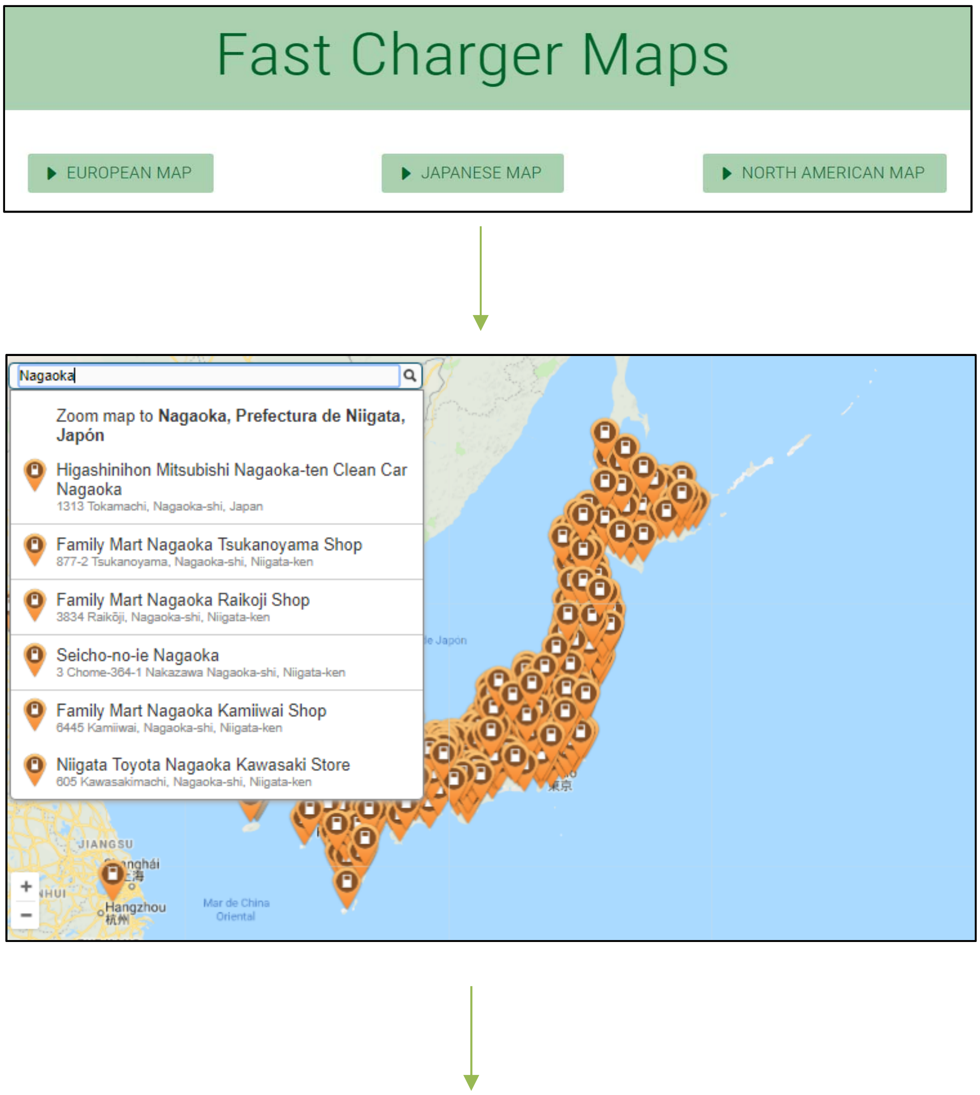
CHAdeMO association is using the subsidies given by METI to establish a huge net of fast charging stations all around Japan, 7100 fast charge points and increasing year per year.

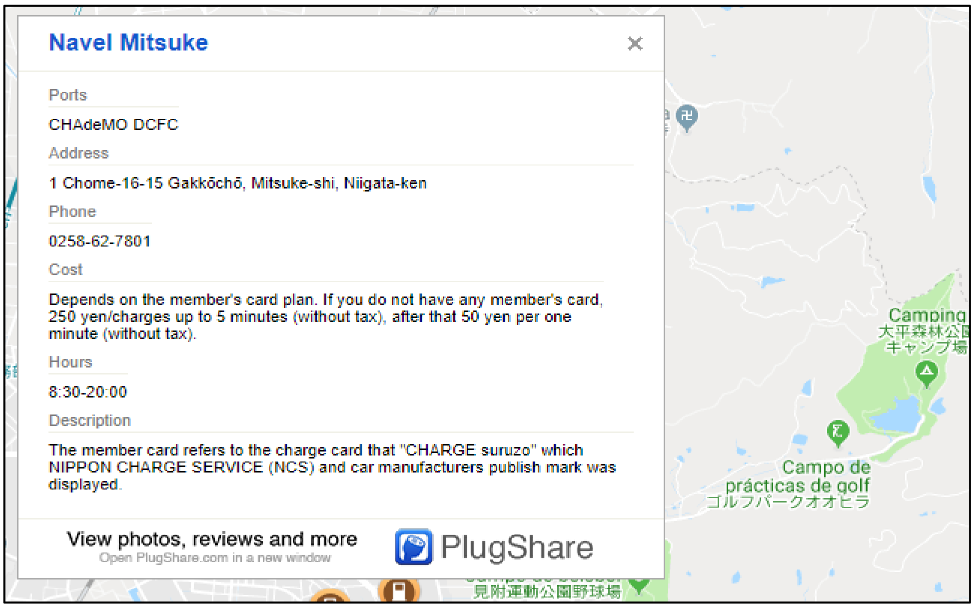
The creation of CHAdeMO association shows the involving of the private companies to improve the EV penetration in the market and reflects a win to win for the Japanese Government and CHAdeMO association for they own interests.

5.2.1.2 National database for EVSE

Japan Government does not have any official company to provide their population the location and characteristics of the fast charging stations but as most of the charging stations are owned by CHAdeMO, this provides a map on the web page to locate and find the kind of ports, address, contact phone, cost, opening time and description of the charging points. CHAdeMO web page redirects the consumer to PlugShare web page, a world-global company that provides the location, photos…etc of many charging stations. In next images, the procedure to find characteristics of one particular charging station through CHAdeMO map is shown.

Figure 9. Web procedure to find characteristics of charging stations in Japan.





Note: First step searching for the continent map, the second step looking for the location using the browser, third step, chosen charging station Specifications.

Source: CHAdeMO Association Web, 2017.

5.2.1.3 Information provided by METI to municipals

Ministry of Economy, Trade and Industry (METI) has developed the idea to transfer their knowledge about the establishment of charging stations in Japan to municipal population to motivate people install charging stations and avoiding the “fear of new technology”, they provide three types of knowledge.

- Installation method of charging facilities: METI prove to population all the information needed to develop the installation of the charger.
- Hints on appropriate places for installing chargers: METI provide to population the bests locations to install chargers using the background of the mathematic procedures, involving traffic and spaces, for placing charging stations in large cities, main roads and medium and small cities developed by METI researchers.
- Measures to for keeping running costs low: METI provide to population the knowledge of the best type charger for keeping the running costs low according the needing of the final supply to the client.

5.2.2 Evolution of measures to increase EV stock

As well as Norway and Spain, Japan has measures to increase the sales of the electric vehicle. But unlike Norway and Spain, all of them are fiscal incentives reduction of purchase price and not direct subsidies to usage costs and range challenges or reduction of time costs and relative advantages. In the following table we can see the fiscal incentives and subsidies for reduction of purchase price offered by the Japanese government to its population.

Table 11. National incentives and policies in Japan

Incentives	Year
Fiscal incentives and subsidies reduction of purchase price	
Acquisition tax reduction	2001
Automobile tax	2003
Automobile weight tax	2009
Subsidies	2009
Direct subsidies to users reducing usage costs and range challenges	
--	
Reduction of time costs and giving relative advantages	
--	

Source: Guide centre for car inspection and car procedure of Japan Web, 2018.

Automobile tax and Automobile weight tax are payed, for traditional vehicles, in the purchase moment and periodically during the first 10 years. These will be in the purchase moment (year zero), and 3th, 5th and 9th years.

5.2.2.1 Fiscal incentives reduction of purchase price

5.2.2.1.1 Acquisition of tax reduction (2001)

Automobile acquisition tax is payed by the automobile's acquirer in the purchase moment. The tax rate differs between when you purchase on a new car and when you purchase with a used car, and even in a used car, it differs between the case of a new year type and the case that the elapsed years have passed. However, in this project only the new car tax will be used. Automobile acquisition of tax is taxable for cars and mini vehicles.

According to Guide centre for car inspection and car procedure (Annai-center) responsible association for automobile taxes in Japan, the calculation formula of car acquisition tax for a car passenger and private use of new car is as follows.

Acquisition tax base amount + value of added item = acquisition price (rounded down to less than 1,000 yen)
Acquisition price × 3% = automobile acquisition tax amount

The acquisition tax base amount is calculated as de 90% of the initial price of the car (no taxes) without any extra car-item. The official acquisition tax base amount is the 90% of the initial price of the vehicle because they are already assuming a discount of 10% in the moment of the purchase. Following, all the navigation systems, car stereos and luxury items equipped as an option will be added to the acquisition tax base amount and this result will be called Acquisition price. Finally, the 3% of the acquisition price according to Guide centre for car inspection and car procedure of Japan, is the Automobile acquisition tax amount that the buyer will need to pay.

In case of Gasoline cars, a discount of 60% of the Automobile Acquisition tax final amount will be applicated. PHEV and EV have a 100% discount of the Automobile acquisition tax.

5.2.2.1.2 Automobile tax reduction (2001)

Automobile tax is afforded by the car’s purchaser. The amount of tax varies depending on the application and the amount of exhaust, and some tax-reduced vehicles (such as electric cars and hybrid cars) are subject to tax reduction. In table 12 different amounts of Automobile tax depending on the consume are shown.

Table 12. Amount of Automobile tax depending on the vehicle consume (JPY).

Consumption (L/100km)	*Price*
1,0 or Less	29.500
More than 1,0 to 1,5	34.500
More than 1,5 to 2,0	39.500
More than 2,0 to 2,5	45.000
More than 2,0 to 3,0	51.000
More than 3,0 to 3,5	58.000
More than 3,5 to 4,0	66.500
More than 4,0 to 4,5	76.500
More than 4,5 to 6,0	88.000
More than 6,0	111.000

Source: Guide centre for car inspection and car procedure of Japan Web, 2018.

The automobile tax amount for an EV (1.0 L or less) is 29.00 JPY (227 €) with a later 75% applied discount (Table 13). The payment is in the purchase moment (year zero), and 3th, 5th and 9th years and will be sent by automobile tax office and city tax comprehensive administrative centre jurisdiction. In the next table we can see the reductions depending of the type of car.

Table 13. Reduction of the Automobile tax depending on the type of car.

<table>
<tr><th colspan="2">Target condition</th><th>Mitigation measures</th></tr>
<tr><td colspan="2">▪ Electric car
▪ Fuel cell vehicle
▪ Natural gas car※
※Heisei era 2009 regulation NOx reduction by 10% or more, or conforming to the exhaust gas regulation in 1993
▪ Plug-in hybrid car
▪ Clean diesel passenger car※
※Compliant with exhaust emissions regulations in 2009 or compliance with exhaust gas regulations in 1993</td><td>About 75% tax reduction</td></tr>
<tr><td rowspan="2">Gasoline car · LPG car (including hybrid car)※
※Heisei era 2005 regulation 75% reduction, or exhaust gas regulation in 1990 50% reduction</td><td>FY2003 Fuel consumption standard + 30% achieved</td><td>About 75% tax reduction</td></tr>
<tr><td>FY2003 Fuel consumption standard + 10% achieved</td><td>Approximately 50% tax reduction</td></tr>
</table>

Source: Guide centre for car inspection and car procedure of Japan Web, 2018.

5.2.2.1.3 Automobile weight tax (2009)

According to Annai-center, Automobile weight tax is taxed according to the classification and weight of automobiles. For car passenger automobiles the tax amount increases every 0.5 tons of vehicle weight (Table 14).

In the method of paying the automobile weight tax, we will apply tax payment by stamping the stamp of the amount equivalent to the automobile weight tax on the automobile weight tax payment form at the time of vehicle inspection, modification of the car or new registration. In addition, refund can be received by submitting applications if the car waste disposal procedure and dismantled car satisfy the prescribed conditions. The Automobile weight tax payment is in the purchase moment (year zero), and 3th, 5th and 9th years, those years normally match with the moment of the general inspection of the car. EV has a 100% automobile weight tax exemption.

Table 14. Automobile weight tax amount list of private passenger cars (JPY).

Automobile weight tax amount list of private passenger cars (capacity 10 people or less) in **2 years (vehicle inspection conducted)**

Vehicle weight	2 years (vehicle inspection conducted)				
	Eco car reduction application	No eco car reduction			
		Eco car (principle tax rate)	Other than eco car		
	duty free		Less than 13 years	13 years elapsed	18 years elapsed
~ 500 kg or less	0	5,000	8,200	11, 400	12,600
~ 1,000 kg or less	0	10,000	16,400	22,800	25,200
~ 1,500 kg or less	0	15,000	24,600	34,200	37, 800
~ 2,000 kg or less	0	20,000	32,800	45,600	50,400
~ 2,500 kg or less	0	25,000	41,000	57,000	63,000
~ 3,000 kg or less	0	30,000	49, 200	68,400	75,600

Source: Guide centre for car inspection and car procedure of Japan Web, 2018.

5.2.2.1.1 Subsidies (2010)

Since 2009 Japanese Government through the Ministry of Economy, Trade and Industry of Japan (METI) has been supporting the increase of Electric vehicles with subsidies for the plug-in electric vehicles to reduce the difference between ICE price and PEVs price.

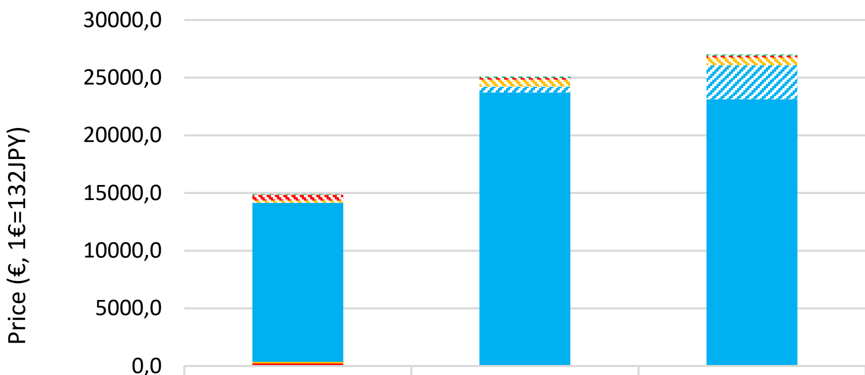
For the EVs, since 2009 to 2015 the subsidies were 510.000 JPY (3920€) per unit vehicle while in 2016 the subsidies strategy changed depending on the battery volume of the purchased vehicle. According to NEV (2017) until 2016, 133.429 number of subsidies were given. The amount of 11.000 JPY (84,57€) per kWh was the new subsidy, for example, in the case of Nissan Leaf with a 30kWh battery volume, a subsidy of 330.000 were given to the customer. In 2017, against the decrease of the EV market share (graphic 50-51), the subsidy strategy changed again. So, the new subsidy strategy was based on the total range of the vehicle and the amount given was 1000 JPY/Km (7,73€/km). Using the same Nissan Leaf example, with a full charged range of 400km the subsidy given in the purchase moment was 400.000 JPY (3075,2 €). As we can see, the value of 2017 subsidy is lower than 2015, but market share in 2017 had a huge increase, that fact would be because from 2015 to 2017 1.255 number of CHAdeMO fast charging stations were build and within this 2 years, population has been adapting to EV new technology and habits.

From 2009 to 2017, the total budget for subsidies in promoting electric vehicles by the Japanese Government has been a medium amount of 450.000 JPY per vehicle and 200.000 approx. subsidized, so, the result is 90 billion JPY (694,98 million €).

5.2.2.1.4 ICE/PEV comparation purchase price of private passenger car in 2018.

In this part of the study we will compare the final purchase price of Gasoline Vehicle, Plug-in Electric Vehicle, and Electric Vehicle considering the fiscal incentives that Japanese Government use to support the increase of the EV stock, Acquisition tax reduction, Automobile tax reduction and Automobile weight tax reduction and subsidies.

Graphic 27. Summary of purchase direct incentives for private passenger cars with different engine vehicles in Japan (EUR).



	Gasoline	PHEV	EV
Automobile wight tax reduction	55,6	111,1	111,1
Automobile tax reduction	488,9	163,9	163,9
Acquisition tax reduction	206,9	603,9	650,6
Subsidy	0,0	505,2	2963,0
V.unit price (+consumption tax-subsidy)	13792,0	23650,4	23061,0
Real Acquisition tax	137,9	0,0	0,0
Real Automobile tax	163,0	54,6	54,6
Real Automobile weight tax	55,6	0,0	0,0

Mid-size vehicle

Note: Mid-size vehicle specifications; Automobile tax category: 4,5L to 6.0 L. Automobile weight tax category: 1500km or less.

Source: Own creation using data from Guide centre for car inspection and car procedure (Annai-centre), Ministry of Economy, Trade and Industry (METI).

On the first hand, we can see in the graphic 63 that both PHEV and EV base prices are much higher than the Gasoline vehicle base price. On the other hand, it seems that fiscal incentives have low impact and are not balancing enough the different prices and as a consequence Gasoline vehicle's price keeps high comparing to PHEV and EV price.

5.2.2.1.5 ICE/PEV Comparation purchase price and usage cost from 2018.

For this calculation, we have assumed a 5,0 L/100km consumption of gasoline for the gasoline vehicle and an average price for the gasoline in Japan for the consumer (with taxes) of 141JPY/L (1,70 €/L).

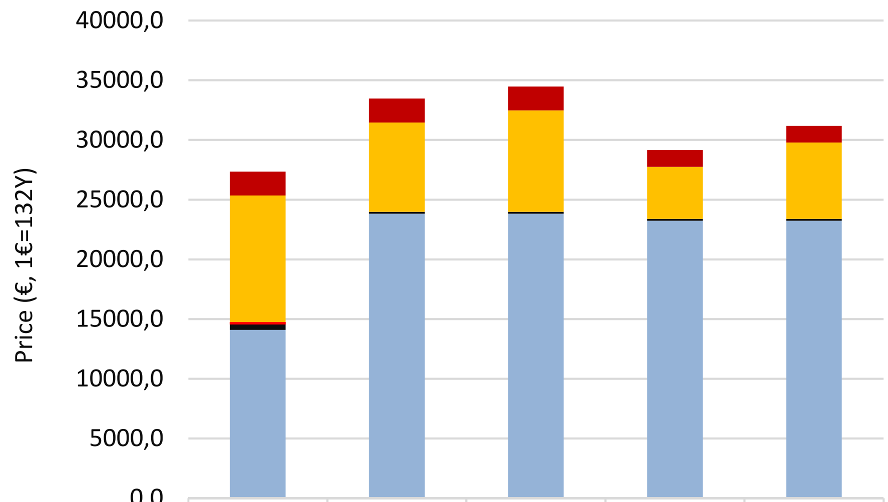
For the plug-in hybrid car (PHEV gasoline have assumed half kilometres with gasoline and half with electricity. We have assumed the same values as in Norway for consumption of gasoline of 3.4 L/100km and 14.4 kWh/100km of electricity. In the charging at home calculation electric price will be 22.1 JPY/kWh (0,163 €/kWh). On the other hand, in the calculation that we assume the vehicle always charges using fast charging stations charging price depends of FCS's owner. In this case we have used 0,24€/kWh, the price of the Superchargers of Tesla.

For a mid-size electric car (EV) we have assumed a 13 kWh/100 consumption. Electricity prices for charging at home case and Fast charging station case are the same than PHEV's prices.

About the maintenance cost we will use the same values than Norway. The price of the maintenance cost for 200.000km mid-size electric vehicle is about 30% less than the Gasoline vehicle. The maintenance cost of a medium size Gasoline vehicle (Renault CLIO IV) without any reparation costs is 260.160 JPY (2000€), so, the maintenance cost of Electric vehicle is 182.000 JPY (1400€) (Renault ZOE).

Graphic 28 Show the comparison between the Gasoline vehicle, PHEV and EV. The used purchase cost value is the result of the Graphic 27.

Graphic 28. Comparison between the Gasoline vehicle, PHEV and EV purchase and usage costs in Japan.
Units: EUR



	Gasoline	PHEV (Home)	PHEV (FCS)	EV (Home)	EV (FCS)
Maintenance	2000,0	2000,0	2000,0	1400,0	1400,0
Usage costs (200,000km / 10 years)	10601,5	7478,0	8492,8	4354,5	6384,0
Automobile weight taxes	166,7	0,0	0,0	0,0	0,0
Automobile taxes (3th,5th,9th years)	488,9	163,9	163,9	163,9	163,9
Purchase cost (including taxes exemptions)	14080,8	23816,1	23816,1	23226,8	23226,8

Midium size vehicle

Note: Mid-size vehicle specifications; Automobile tax category: 4,5L to 6.0 L. Automobile weight tax category: 1500km or less.

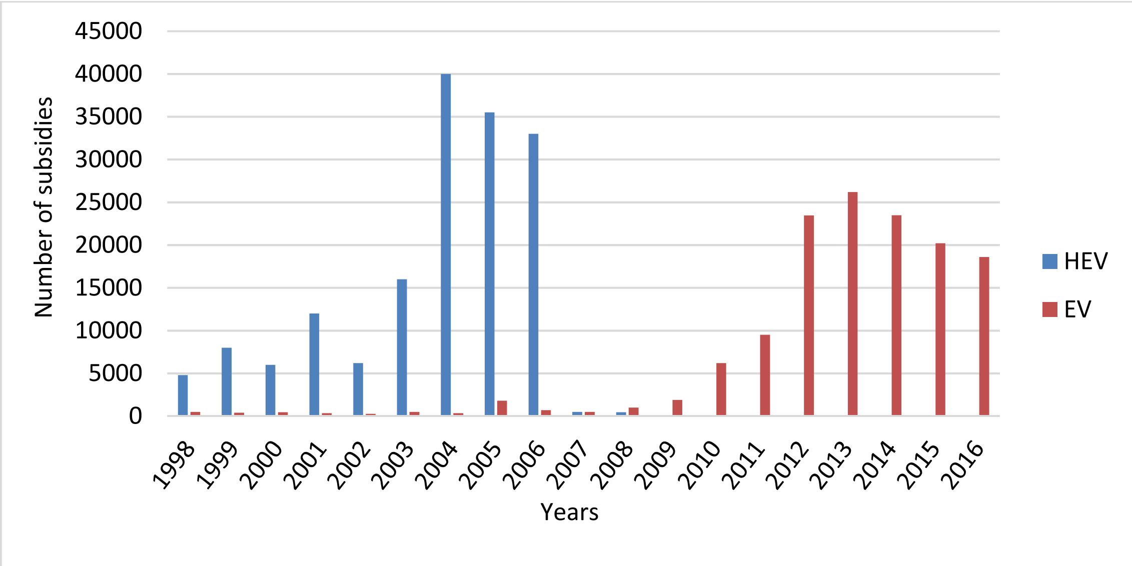
Source: Own creation using data from Guide centre for car inspection and car procedure (Annai-centre), Ministry of Economy, Trade and Industry (METI).

As we can see in the graphic above, after 10 years of using the different types of vehicles, the total price adding the purchase price and the price of use with all the respective taxes is more equal in different types of vehicles. We can point out that the difference in Japan of charging the vehicle always at home or always in a fast charging station does not mean a big difference of consumption use.

5. 3 Inflection point from HEV to EV

In the case of the Japanese analysis is it important to say that Japanese Government has been subsiding Hybrid vehicles from 1998 what shows the responsibility with the environment that Japan has been carrying. Japan nowadays have a 34,9% market share of HEV, with a 10% stock of total passenger vehicles, some of the highest percentage in the world. In the next graphic we can see the evolution of the HEV from 2010 to 2016.

Graphic 29. Number of subsidies for HV and EV from 1998 to 2011 in Japan.
Units: Number of subsidies



Source: Next Generation Vehicle Promotion Center Web, 2018.

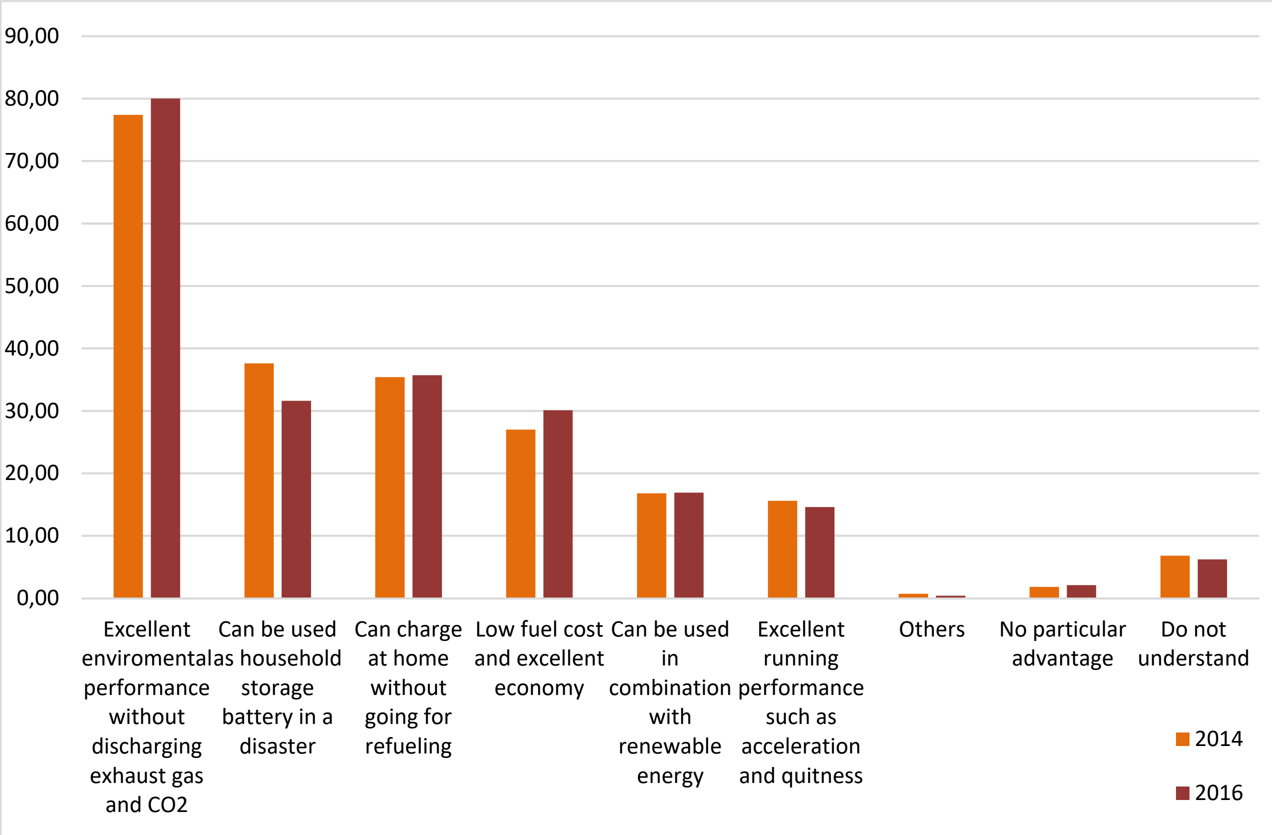
As an important reflection to highlight in the Japanese Government, we see in graphic 29 how the subsidies given for the purchase of HEV vehicles in 2006 change as the subsidies destined for EV begin in 2009 marking a turning point in the ideology of the establishment of the electric vehicle as a priority. Even thought, the importance of the decreasing of GHG is in population mind as a priority that is reflected in Japanese population effort buying HEV vehicles.

5.4 Japanese population pros and cons of EV

The most important information to guaranty an efficient EV establishment is to know how people react to the different incentives and which ones are the most important reasons for population to make the adaptation easier.

Graphics 30,31,32,33 show a survey made in Saitama prefecture in 2014 and 2016 show the opinions of 3,339 people about different questions related to EV advantages, best points in the moment of the EV and PHEV purchase and how to make EV and PHEV more popular. Interviewed people could choose 3 elements in each question, the percentage shown in each element means the percentage of people who chose each element.

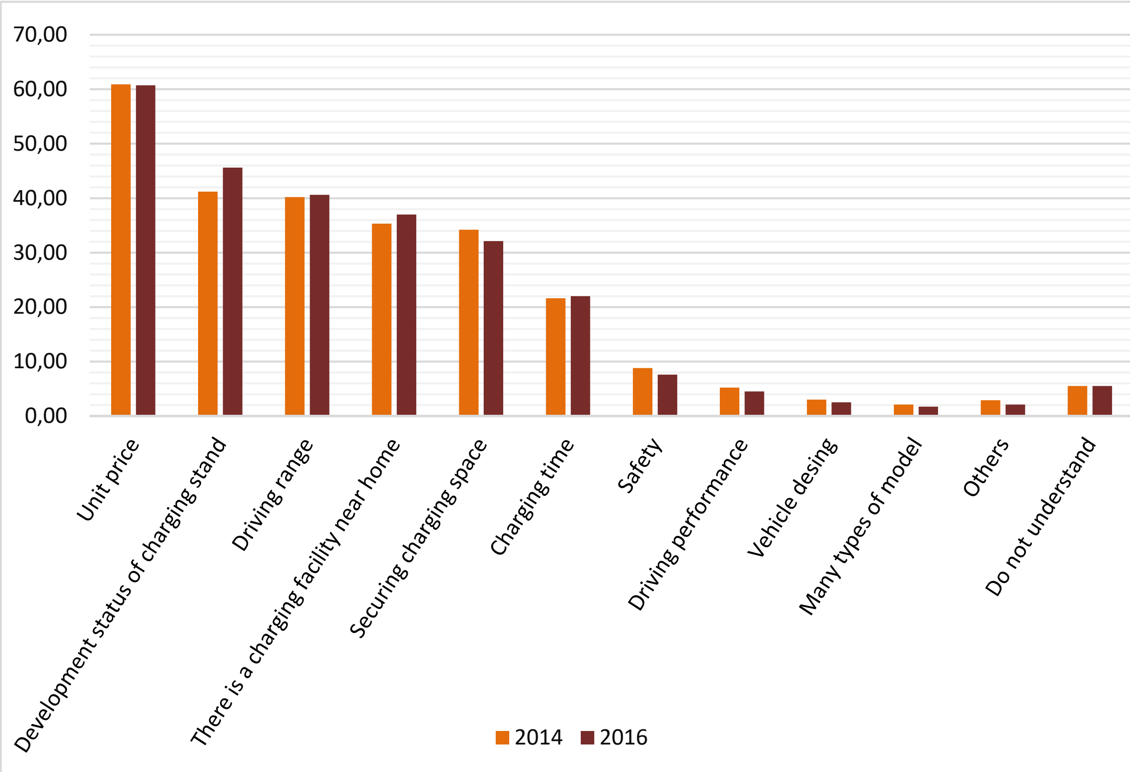
Graphic 30. Saitama prefecture survey results: *What do you think of EV as an advantage?* (Multiple answers permitted)
Units: Percentage of people who chose each option (%)



Source: Saitama Prefecture Online Surveys Web, 2018

The most important advantage for Japanese population in Saitama prefecture is the Excellent environmental performance without discharging exhaust gas and CO_2 with a 77,40% (2014) and 80% (2016). Second, third and fourth advantages have a very similar score in valuation. The second important advantage is that in case of disaster, the battery of the EV can be used as a household storage, 37,60% (2014) and 31,60% (2016). This second valued advantage reflects the conscience of Japanese population against the constant earthquakes suffered in Japan that other countries might not value in EV. The third of most valued advantages is the possibility of charging the vehicle at home without going for refuelling with 34,40% (2014) and 35,70% (2016). Finally, Japanese population in Saitama prefecture value in fourth place the low fuel cost (electricity) and excellent economy with 27% (2014) and 30,10% (2016). The rest of possible advantages are under 15% valued and don't reflect a special interest in Japanese population. Surprisingly Japanese population in Saitama don't see the most important advantage the use of the renewable energies for the electricity generation for EV.

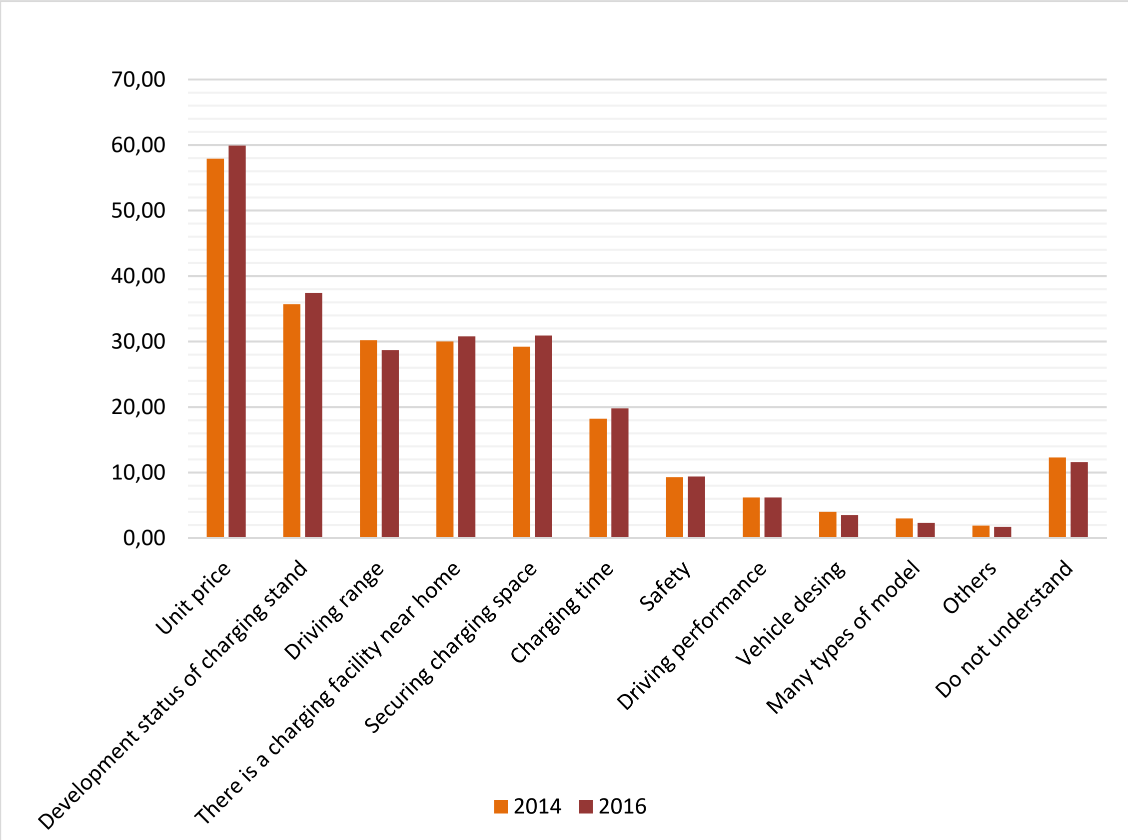
Graphic 31. Saitama prefecture survey results: *When you consider purchasing an EV, which elements are more important?* (Multiple answers permitted)
Units: Percentage of people who chose each option (%)



Source: Saitama Prefecture Online Surveys Web, 2018

The most important element for buying an EV for Saitama prefecture population are the Unit price with a 60,90% (2014) and 60,70% (2016). This fact agrees with the results of the Gasoline and EV obtained in the graphic 63, the EV purchase price is approximately a 54% (no subsidies) more expensive than the Gasoline's. In the second place of the most appreciated elements the development status of charging stand takes place with a 41,20% (2014) and 45,60% (2016). Even though Japan has a huge net of charging stations, their population require a most extended one and reflects that the rate of PEV per EVSE is still high. The third of the most important element is the driving range, Japanese population in Saitama appreciate a long driving range of electric vehicle with a 40,20% (2014) and 40,60% in (2016). The fourth most appreciated element to buy an EV is the availability of a charging facility near their houses with a 35,30% (2014) and 37,00% in (2016). The fifth and with very similar value than the fourth, Saitama prefecture population appreciate de security of the space where they are charging their EV with 34,20% (2014) and 32,10% in (2016). Finally, and surprisingly charging time is valued with 21,16% (2014) and 22,00% (2016), that fact means that for Japanese population in Saitama prefecture the charging time of an EV is not one of the most important elements for the purchasing of the EV, however, globally, this is one of the main concerns of the EV. That reflects the willingness of sacrificing their own personal time to contribute to the Japanese society and environment.

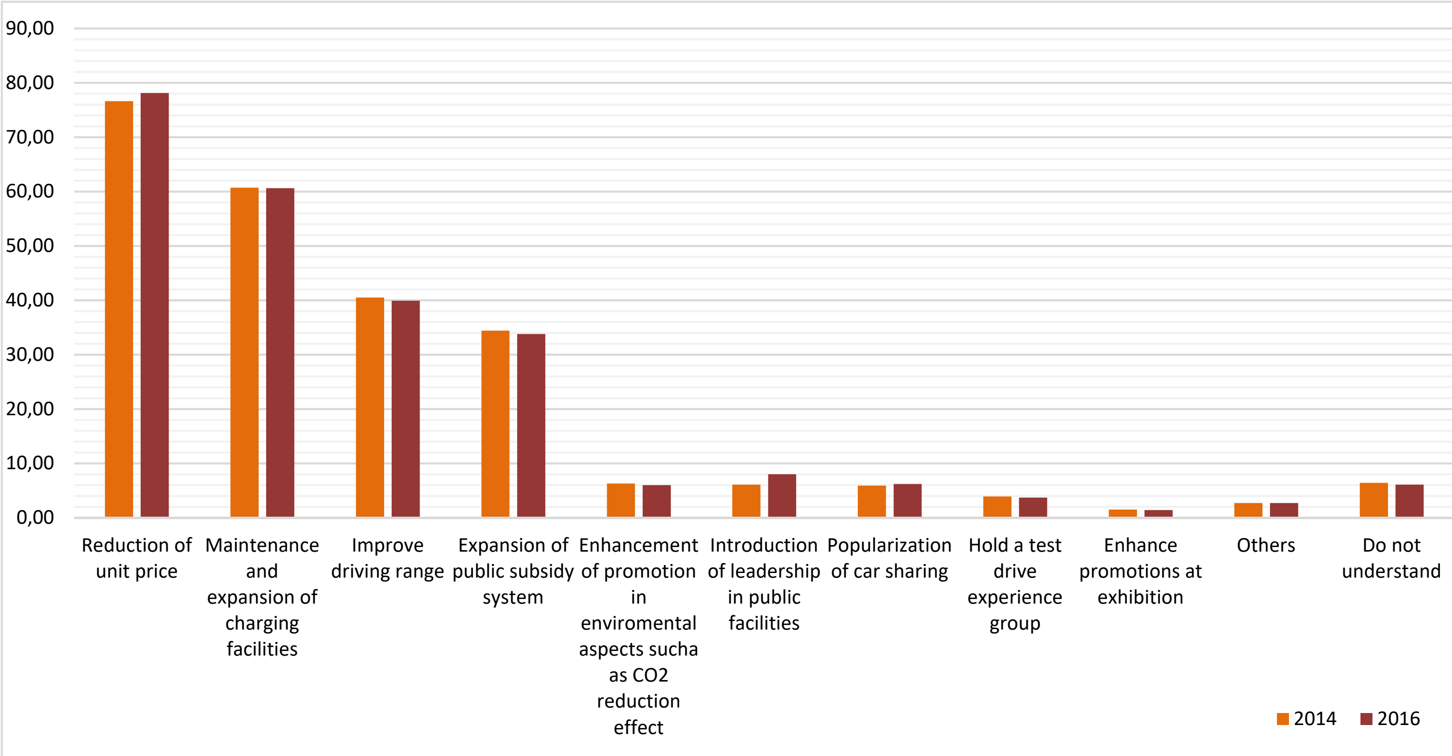
Graphic 32. Saitama prefecture survey results: *What do you care about when considering purchasing PHEV?* (Multiple answers permitted)
Units: Percentage of people who chose each option (%)



Source: Saitama Prefecture Online Surveys Web, 2018

The opinion of the Japanese population of Saitama prefecture of the most important points to buy PHEV are almost the shame than EV. As is normal because of the higher range of PHEV in comparison with EV, the development status of charging stand and driving range are 5-10 percentage points lower in PHEV case.

Graphic 33. Saitama prefecture survey results: *What do you think is necessary to make EV & PHEV more popular?* (Multiple answers permitted)
Units: Percentage of people who chose each option (%)



Source: Saitama Prefecture Online Surveys Web, 2018

To popularise the EV and PHEV, Japanese population from Saitama prefecture thinks with a 76,60% (2014) and 78,10% (2016) that the reduction of the unit price of the EV and PHEV would be the best measure, as we already expose, the price, without subsidies of PHEV and EV are 50-55% approx. higher than the Gasoline prices. Surprisingly, the second measure to popularise PHEV and EV for Saitama prefecture population is the maintenance and expansion of charging facilities with 60,70% (2014) and 60,60% (2016), even though Japan owns 7100 fast Charging points established in Japan, Japanese population show the lack of charging facilities in this survey. In third place, the improving of driving range is valued with 40,50% (2014) and 39,90% (2016) for Saitama prefecture population, they think that an improvement of the range is needed to popularise the PHEV and EV. Finally, the fourth important measure to popularise PHEV and EV is the expansion of public subsidy system with 34,40% (2014) and 33,80% (2016) which agrees with the value of the purchasing car with subsidies obtained in Graphic 63, even though public subsidies are given to PHEV and EV buyers, the amount is not enough to balance the price of Gasoline vehicle, PHEV and EV. The PHEV price with subsidies is approx.42% higher than Gasoline price while the EV price with subsidies is approx. 40% higher.

5.5 Japan Conclusions

Japan involvement in electric engine vehicles appeared two decades ago. Since 1990 Japan subsidized the purchase of non-plugged hybrid electric vehicles showing the strong compromise with the environment and was not until 2008 when a change in subsidies objectives took place changing from non-plugged hybrid electric vehicles to plug-in electric vehicles creating an inflection point.

Japan electric vehicles fleet is one of the most important in the world just beside USA and China with a total of PEVs of 200.000 vehicles. Through the investment of 1000 million EUR focused on the increasing of charging infrastructure, Japan normal charging stations reach an amount of 33.000 stations and because of the public-private agreements with CHAdeMO association the number of fast charging stations across the country reaches the amount of 7100. Both normal and fast charging stations together represents a 41.000 charging stations, which is higher than the total number of gas stations in Japan. Even though surveys suggest a more exhausted charging infrastructure network, these facts show the big effort of Japanese Government to facilitate the penetration of electric vehicle in the current market.

Even though nowadays PEVs represents a 1,6% market share, and that would seem a small indicator, from 2016 to 2017 Japanese market share of PEVs grows a 57,83%.

Regarding to public opinion of fiscal incentives offered by Japanese Government, inhabitants of the survey sample in Saitama prefecture show disagree with the electric vehicle and plug-in electric vehicle actual purchase price in comparison with gasoline price. As we analysed in the comparative purchase price of a mid-size and mid-class of different types of vehicle chapter, EV purchase price with all the fiscal incentives and subsidies is 39% higher in comparison with same specifications gasoline vehicle. The disagree with the Japanese Government fiscal incentives and subsidies is based on the idea that the 14,6% of the reduction price that fiscal incentives and subsidies achieve is not enough to balance the price of EV vehicle and Gasoline vehicle.

About the purchase and usage price comparison, the EV, PHEV and Gasoline vehicle total price is more balanced. This balance is mainly due to the low cost of the electricity charging in comparison with the gasoline price and not achieved by the fiscal incentives and exemption of annual taxes that Japanese Government offers. However, Japanese population don't appreciate the lower price of electric-fuel as much as the purchase total price.

Setting aside the different price of EV and Gasoline vehicle Japanese population is increasing the EV and PHEV market share. As the survey done in Saitama prefecture, Japanese population is very concerned about the excellent environmental performance without discharging exhaust gas and CO_2. Furthermore, Japan is also a very attacked country by natural disasters like earthquakes, this fact is reflected in the surveys, the second most important advantage for Japanese population is EV can be used as a household storage battery in a disaster situation.

6. Spain EV analysis

The objective of this project is to analyse and think about what Spain is implementing in terms of policies, subsidies and advantages of EV to guaranty a successful EV establishment in comparison with Norway and Japan. Nowadays Spain only has a 0,1% of PEV share and approx. 20.000 number of PEVs in their roads. Its market share is very low, just a 0,35% of PHEVs and 0,33% of EVs are new registrations respect to the total new registrations in 2017. However, these shares are increasing year per year as we can see in the next part of the study, from 2016 to 2017 total PEVs (PHEVs and EVs) market share has grown a 52%.

Furthermore, Spain is doing a big effort to support EVs incentives in the purchase of the vehicle and the infrastructure support since years ago. Specifically, during 2018 a new plan called MOVALT will be applied. It has a budget of 20 million euros and is intended for individuals and companies, freelancers and public or private entities. It is estimated that a total of 5,600 vehicles will be able to benefit from them.

6.1 Spain status

6.1.1 Spain general data

Spain, officially the Kingdom of Spain is a sovereign state mostly located on the Iberian Peninsula in Europe. The country's mainland is bordered to the south and east by the Mediterranean Sea except for a small land boundary with Gibraltar, to the north and northeast by France, Andorra, and the Bay of Biscay and to the west and northwest by Portugal and the Atlantic Ocean.

Figure 10. Location of Spain in Europe

Source: Google 2018, INEGI, ORION-ME

Table 15. Spain demographic, geographic, economic, transportation and EV data.

Demographic and geographic	
Name	Spain
Capital	Madrid
Population	46.335.000
Total land area (km2)	505.992 km2
Density population	92 pop/km2
Residents in urban settlements	31.507.800 (69%)
Residents in rural settlements	14.827.200 (31%)
Area of urban settlement (km²) (>50.000 pop)	48.575km2 (9,6%)
Number of residents in urban areas	648, 64 pop/km2

Economy	
Gross domestic Product (in billion EUR)	€ 1.410,05
Gross Domestic Product Capita (in EUR)	€ 30.432
Transportation and EV	
Highway (km)	16.214 km
Passenger cars (M1)	22.876.247
Cars per capita	0,49
Electric Plug-in Passenger cars stock(PEV) (M1)	20.000 (0,1%)
PEV/EVSE:	4 PEV/EVSE

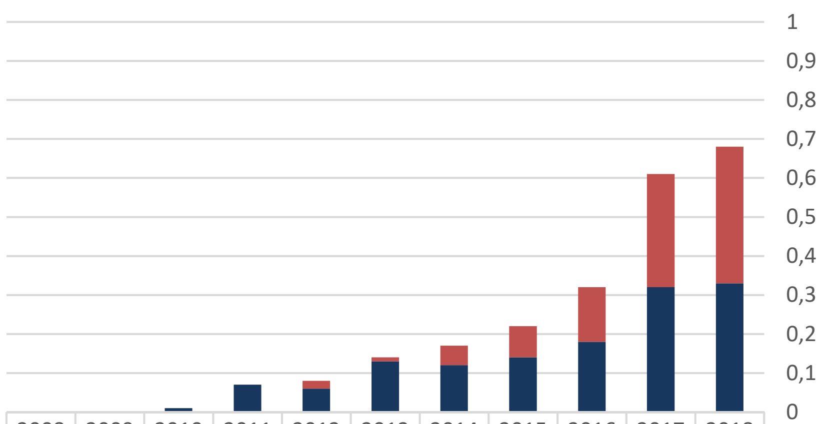
Note: M1: Vehicles used for carriage of passengers, comprising not more than eight seats in addition to the driver's = 9.

Source: Own creation using data from; European Alternative Fuels Observatory Web, 2018 and Ministerio de fomento Web, 2018.

6.1.2 Spain EV statistics

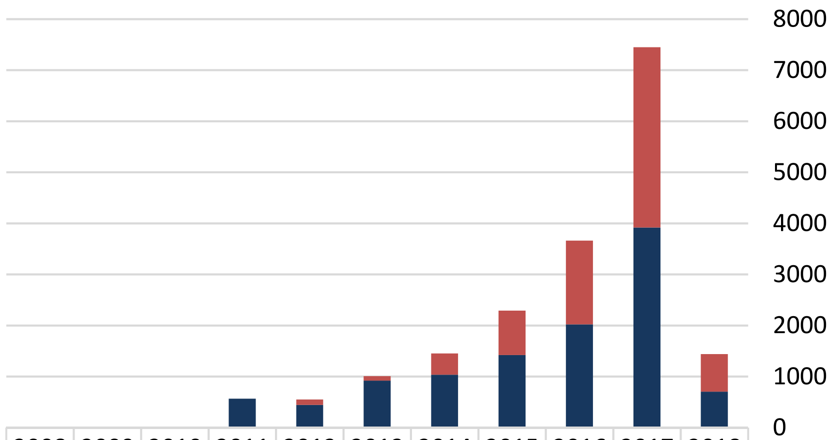
Spain has had a huge increase of the PEV market share from 2016 to 2018. In detail, as we can see in the Graphic 20-21, the PHEV market share has grown from 2016 to a 40% and the EV market a 54,55% according to the data available in the European Alternative Fuels Observatory (EAFO). Although these shares seem to be very optimist, the PHEV market share in 2018 is just a 0,35% while the EV market share is 0,33. These results show that Spain is in the beginning of the Electric Vehicle establishment comparing with the rest of European Countries, specially Norway.

Graphic 30-31. Changes in BEH y PHEV market and stock in Spain from 2008 to 2018.
Units: PEV market share (M1) (20)-New registrations EVs (M1) registrations.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sales rate PHEV (%)	0	0	0	0	0,02	0,01	0,05	0,08	0,14	0,29	0,35
Sales rate EV (%)	0	0	0,01	0,07	0,06	0,13	0,12	0,14	0,18	0,32	0,33

Years



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sales number PHEV	0	0	0	0	109	87	417	869	1641	3528	736
Sales number EV	0	0	0	568	443	921	1035	1422	2021	3920	703

Note*: M1: Vehicles used for carriage of passengers, comprising not more than eight seats in addition to the driver's = 9.*

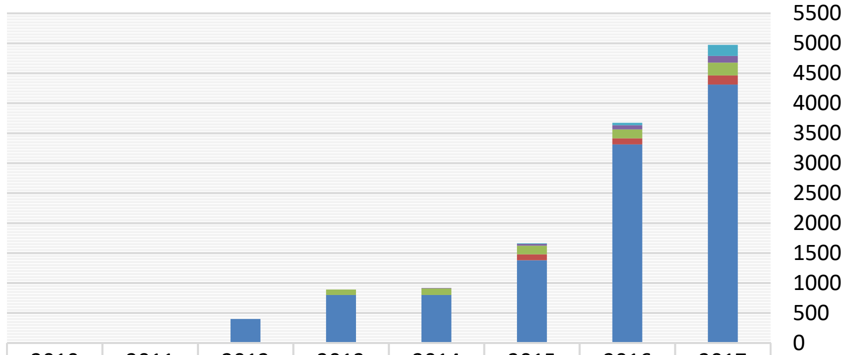
Data source: European Alternative Fuels and Observatory Web, 2018.

As we can see in the graphics above the beginning of the Spanish electric vehicle Establishment is here. While the market share is very low in Spain and a lot of work is needed to be done to reach the level of Norway, Spain is in the right path to finally reach a huge fleet of electric vehicles in its roads in the future.

As we have studied in the Norway Analysis charging stations has a huge impact to Electric Vehicle establishment, especially in initial phases of the establishment.

In the next Graphic we can observe the evolution of the number and type of charging stations in Spain from 2010 to 2017.

Graphic 36. Number and type of public EVSE from 2010 to 2017 in Spain.
Units: Number of charging stations.



	2010	2011	2012	2013	2014	2015	2016	2017
Tesla SC	0	0	0	0	0	12	42	184
CCS	0	0	0	0	9	30	68	114
ChaDeMo	0	0	0	91	109	142	151	213
Type-2AC	0	0	0	0	0	101	101	151
Normal charge (<=22kW)	0	0	400	800	800	1378	3312	4312

Data source: Data source: European Alternative Fuels and Observatory Web, 2018.

As we can appreciate in the graphic below, until 2012 there isn't any Normal charge (<=22kW) point in Spain. This fact is one of the main reasons of the low Spanish market share of electric vehicles. On the first hand, Public charge is very important in the Electric vehicle establishment because most of the people in urban settlements do not have a private place to charge the vehicle every day. Spain only has 4 PEVs per EVSE available, as this number can seem very positive, is just a proportion due to both low levels of PEVs and EVSE and is not relevant. On the other hand, public chargers in the streets are the best way to transmit to the population the support of the government to the Electric vehicle establishment and help to lose the "range anxiety".

6.2 Spanish measures to increase EV establishment

In the chapter above, we have seen the low market share that Spain has nowadays but a great increasing year per year. In this part of the study we will see the effort and support that Spanish government is offering to its country. As we studied in Norway, Spain is also supporting charging infrastructure to increase the number of EVSE and implementing policies and legacies to motivate the people to make the change from traditional vehicle to EVs.

6.2.1 Improving number of EVSE measures

6.2.1.1 Incentives for EVSE establishment

Spain, as Norway, has invested in increasing the number of EVSE in the whole country. Spain has supported charging infrastructure from 2009 with a plan first called MOVELE for non-enterprises vehicles and PIMA Air for enterprises vehicles to 2016, then new plan called MOVEA in 2017 and MOVALT in 2018 were created.

The first plan, MOVELE, comes into effect in 2009, it was the budget destined to cover this item of subsidies was endowed with a total of 10 million Euros, of which 8 million will be destined for the direct helps for the acquisition of electrical vehicles and *1,5 million* were destined to the extension of the networks of it recharges in different Spanish cities and the remaining ones 500.000 € were destined to the expenses of management of the project. Thought the plan was supposed to finish in 2010, Nevertheless in 2012 it was possible to request the helps for the purchase of electrical vehicles, since the budget still has not been exhausted due to the scanty demand on the part of the beneficiaries.

From 2012 to 2016 MOVELE has been renewed with an investment of 10 million € per year, however just a 15% of these amounts were infrastructure support and all other amounts were subsidies for the purchase of electric vehicle. A support of 1000€ to install an electric charger at home was available from 2012 for all electric owners.

In 2017, the plans of incentives for the purchase of electrical vehicles MOVELE and of a renovation of commercial vehicles plan called PIMA Air were fused in one only plan that had the name MOVEA which included all the vehicles with alternative energies with a total amount of 20 million € of investment, this investment was only for purchasing subsidies and didn’t support charging infrastructure.

Nowadays in 2018, 35 million € were invested in the MOVALT plan, 20 million€ for the MOVALT-vehicles and 15 million € for MOVALT-infrastructures and a line of support provided with other 15 million Euros to initiatives of I+D+i linked with the efficient mobility energetically and sustainable, total of 50 million EUR.

Related to EVSEs, the funds of MOVELE and MOVALT aimed to increase the EVSE establishment has been an amount equivalent to 60% of the eligible investment (VAT or IGIC not included) in the case of public entities that do not develop any type of commercial activity and Small Businesses and a 40 % of the eligible investment (VAT or IGIC not included) for the rest of the companies

Both years, 2017 and 2018 all resources were drained in less than 24h. This fact shows the inefficient and insufficient investments from the Spanish government to improve the EVs establishment.

The two main electric companies in Spain are Endesa and Iberdrola and both of them are promoting electric vehicle infrastructure. In 2018-2020 Iberdrola will install up to 16,000 electric vehicle recharging points in Spanish homes and another 9,000 infrastructures in the companies that want to offer this service to its employees and customers.

As Iberdrola announced, *"Framed within the 'Smart Mobility' plan, the project will include both the electric recharge infrastructure and its installation and warranty, as well as a personalized supply contract for each client and the possibility of operating it remotely and in real time through an application for mobile phones".*

Endesa, and the entire Enel group, are committed to promoting electric mobility as a key tool in the fight against climate change. Thus, in its strategic plan 2018-2020, presented at the end of November last year, an initiative was included to do so, with the goal of installing 600 public recharging points in the country in the next three years.

6.2.1.1 National database for EVSE

When it's time to talk about National database that allow the EV owners to find the EVSE available in their zone or their destiny Spanish Government hasn't got any official programme or database to do it. Each private company can provide their map to find their own EVSE like Endesa or Iberdrola does and there are Smartphone application that can provide information to find those EVSE such as "openchargemap", a public crowd information system or "electromaps" a private enterprise, however this information cannot be strictly well update and it is not official.

6.2.2 Evolution of measures to increase EV stock

As we have seen in Norway, Spain has also established fiscal incentives and subsidies for the reduction of the purchase price of the electric vehicle, direct subsidies to users to reduce the usage cost and range challenges and reduction of time costs and giving relative advantages to promote electric vehicles acquisition. Spain is one of the most sub-divided countries by autonomous communities which each one of them can have individual incentives. In the next Table we can appreciate the list of the national Spanish incentives and Madrid and Catalonia autonomous community regional incentives.

Table 16. National and Regional incentives and policies in Spain for EV.

Incentives	***Year***	***Regional***		
		S	M	C
Fiscal incentives reduction of purchase price				
Exemption from registration tax	2008			
Bonification of IVTM	2004			
Reduction of IRPF tax in company vehicles	2014			
Direct purchase subsidies	2009			
Direct subsidies to users reducing usage costs and range challenges				
Free toll roads in week days	2015			
"Supervalle electric fee" (01 a.m – 07 a.m)	2012			
Reduction of time costs and giving relative advantages				
Access to bus VAO lanes	2015			
Access to APR's (Residential priority Areas)	2015			
Free parking	2014			
Free charging	2013			

Notes: S: Spain, in all the State, M: Madrid autonomous community, C: Cataluña autonomous community. N1: Vehicles used for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes. (Pick-up Truck, Van)

Data source: Own creation using data from; Ministerio de Economía, Industria y Competitividad and Renault. 2017. "Cámara de Comercio de España Comisión de Energía." *Tesla S* and DOG. (2007). I. Disposiciones Generales. *Dog*, *96*, 8866–8877.

6.2.2.1 Fiscal incentives reduction of purchase price

6.2.2.1.1 Exemption from registration tax (2008)

The special tax on certain means of transport, known as Registration Tax, is paid at the time of registration and is calculated according to the CO_2 emissions of the vehicle.

In this way, cars with little or no pollution due to their low CO_2 emissions have significant savings in their registration, becoming free for vehicles with CO_2 emissions of less than 120 gr / km.

The amount to be paid depends on the value of the car before taxes and it is a percentage of up to 14.75% of it. Since 2008, the Law establishes four sections:

- Vehicles with emissions less than or equal to 120 gr / km CO_2, do not pay registration tax.

- For emissions greater than 120 g / km CO2 and less than 160 g / km CO_2, the amount to be paid will be 4.5% of the non-taxes price.

- For emissions greater than or equal to 160 km / h and less than 200 g / km CO_2, 9.75% is paid.

- Cars whose official emissions are greater than or equal to 200 gr / km CO_2, must pay 14.75% of their value for the registration.

6.2.2.1.2 Reduction of IVTM tax (2004)

The tax on vehicles of mechanical traction (IVTM), also called tax horsepower, is a yearly direct tax that taxes the ownership of motor vehicles apt to circulate on public roads, regardless of their class and nature. This tax must be established in a mandatory manner by the municipalities, bodies in charge of the management, inspection and collection of taxes.

The amount paid every year depends on the potency of the engine and it is measured with “horsepowers” using a formulation in function of the cubic capacity ((D·D·n)/2,5) where D is the diameter of the cylinder in inches and in the number of cylinders), shown in the next table for passenger cars.

Table 17. Horsepower Tax (€) in function of the passenger car power.

Type	***Power***	***Tax (€)***
1	<8 tax horsepower	12,62
2	8-11,99 tax horsepower	34,08
3	12-15,99 tax horsepower	71,94
4	16-19,99 tax horsepower	86,61
5	>20 tax horsepower	112,00

Source: Boletin official del Estado, “BOE” núm. 59, de 09/03/2004

Electric vehicles and plug-in hybrid vehicles are exempted of this tax.

6.2.2.1.3 Reduction of company vehicles (IRPF) (2014)

The acquisition of cars by companies for private or mixed use to their employees implies the imputation of a remuneration in kind in the Income tax of these employees.

The annual retribution of the transferred car will be valued at 20% of its cost. In the case of mixed use, only the percentage of private use will be charged. In the case of electric cars, this valuation of compensation in kind can be reduced by up to 30%.

6.2.2.1.4 Subsidies (2009)

In Spain there are two types of different subsidies focused on alternative fuel vehicles. The first MOVELE, since 2009 the Ministry of Energy, Tourism and Digital Agenda approve to allocate funds for the purchase of electric vehicles. As of 2015, the standard is added in which the concessionaire must facilitate the installation of a linked recharge point (MOVALT). In 2016, € 1000 of support for the linked charging point must be discounted by the concessionaire (MOVALT). In 2017, now called the MOVEA plan, it subsidized the purchase of vehicles powered by alternative energies, it sold out its budget of 20 million euros in 24 hours, as happened with the 15 million for the installation of charging points for electric cars. As of June, of 2018, the VEA plan (formerly called MOVALT-vehicles) allocates 16.6 million euros for subsidies for the purchase of alternative vehicles, not specifically electric vehicles, since they also enter the plan, hybrids Plugs, Hybrids, Compressed and Liquefied Natural Gas, Natural Gas Oil. The subsidies range from € 500-18,000 and in the case of the Passenger car they result from € 5,500 plus € 750 optional to scrap the old vehicle and € 1000 provided by the dealer to install a charging point at home.

The Plan PIVE 9 (2018) (efficient vehicle incentive program) can be added to this plan. The new version of the PIVE plan will exclusively reward the purchase of 100% electric cars, pure hybrids or PHV and gas, vehicles that until now were subsidized by the also extinct Movea plan. In addition, only one item of expenditure of 50 million will be budgeted, compared to the 250 that had the PIVE Plan 8, leaving out this time to cars with only gasoline or diesel engines, even the most efficient ones that comply with the Euro 6 regulation. In this way, only buyers of alternative vehicles will be benefited, for which 20 million will be reserved for direct subsidies. The subsidies will be an amount of 1,500 euros of bonus for conventional vehicles and 3,000 euros for family vehicles of more than 5 seats.

To avoid subsidizing luxury cars, when buying an electric car, you can only opt for state aid if the price before taxes is a maximum of 32,000 euros (38,720 euros with VAT). If it's more expensive, there's no help.

Then, a final aid of € 5500, plus € 750 optional to scrap the old vehicle plus € 1000 from the installation of the EVSE from the VEA plan along with € 1500 from the PIVE9 plan is a final subsidy of € 8750 in total per vehicle. However, the small amount allocated to subsidies only allows subsidizing a total of 13,500 vehicles in the PIVE9 plan and 5,600 vehicles in the VEA plan, insufficient funds according to RENAULT (2017) for the exponential establishment suffered by other countries, it also expresses the company a paralysis of the EV market when funds end in such a short time, without continuing sales.

In comparison with other countries, Spain is not investing abundant amounts. In 2017, France invested in aid to purchase a total of 347 million euros, while Germany launched a plan in 2016 endowed with 1,200 million euros until 2020. Also United Kingdom is a good mirror to look at: in 2016, and expanded until 2018, it invested 550 million euros in this type of incentives.

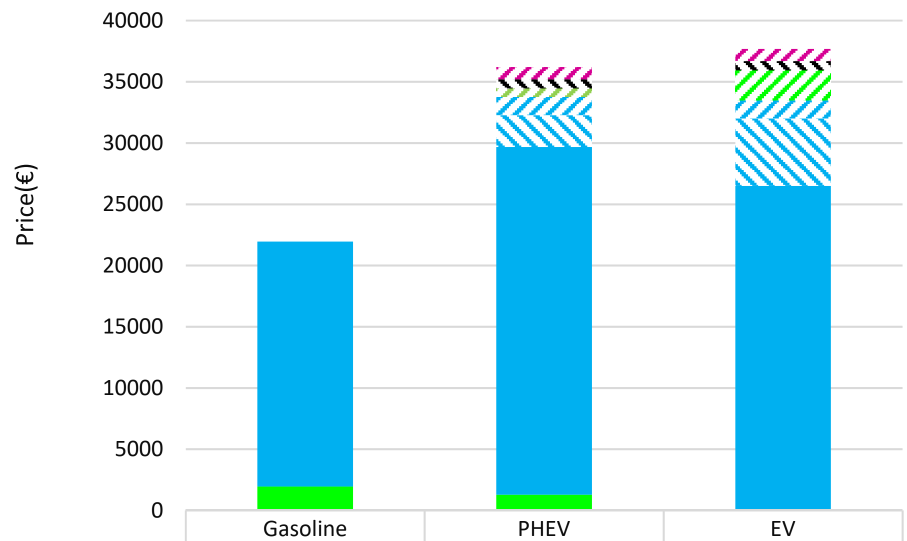
6.2.2.1.5 PEV/ICE private passenger car purchase price comparison in 2018.

Finally, Graphic 37 summarizes the tax incentives in purchase price of medium size different engine cars (Gasoline, PHEV and EV) in Spain. For the Graphic 37 creation the next data has been used:

- In this study the registration tax for Gasoline vehicle is, as an approximation of the medium value is 9,75% and for PHEV is 4,5%.

- The price of the vehicle it's been calculated by the median of different medium size vehicles available in the market which have available Gasoline, PHEV and EV engines in the same model. As a result, the Gasoline vehicle price is 20.000€, PHEV price is +12.500€ respect to Gasoline vehicle and EV price is+13.500€ respect to Gasoline vehicle as well.

Graphic 37. Summary of purchase direct incentives for private passenger cars with different engine vehicles in Spain.
Units: EUR



	Gasoline	PHEV	EV
Charging station VEA (Optional)	0	1000	1000
Scrap bond VEA	0	750	750
Registration tax reduction	0	672	2437,5
PIVE	0	1500	1500
VEA	0	2600	5500
Price (-Subsidies)	20000	28400	26500
Registration tax	1950	1278	0

Medium size car

Data source: Own creation using data from Ministerio de Economía, Industria y Competitividad Web,2018. Renault. 2017. "Cámara de Comercio de España Comisión de Energía." *Tesla S* and own assumptions.

6.2.2.1.6 PEV/ICE private passenger car purchase price and usage cost comparison in 2018

In this part we will summarize the purchase cost and the usage costs. Usage costs are very important to have in account because of the low price of kWh in comparison to de petrol price.

For this calculation, we have assumed a 5,0 L/100km consumption of gasoline for the gasoline vehicle and an average price for the gasoline in Spain for the consumer (with taxes) of 1,24 €/L according to Ministry of energy, tourism and digital agenda in 2017.

For the plug-in hybrid car (PHEV gasoline have assumed half kilometres with gasoline and half with electricity. Finally, we have assumed consumption of gasoline to 3.4 L/100km and 14.4 kWh/100km to Renault (2017). In the charging at home calculation electric price will be using Supervalle tariff to know the lowest price of electric charging, so, the price will be 0,076 €/kWh (ENDESA, 2018). On the other hand, in the calculation we assume the vehicle always charges using fast charging stations. The charging price of depends of FCS's owner, in this case we have used 0,24€/kWh, the price of the Superchargers of Tesla. This price is very competitive and is not the highest one that can be found in Fast charging stations of other companies (Tesla (2017)). and the gasoline price 1,24€/L as in the case above.

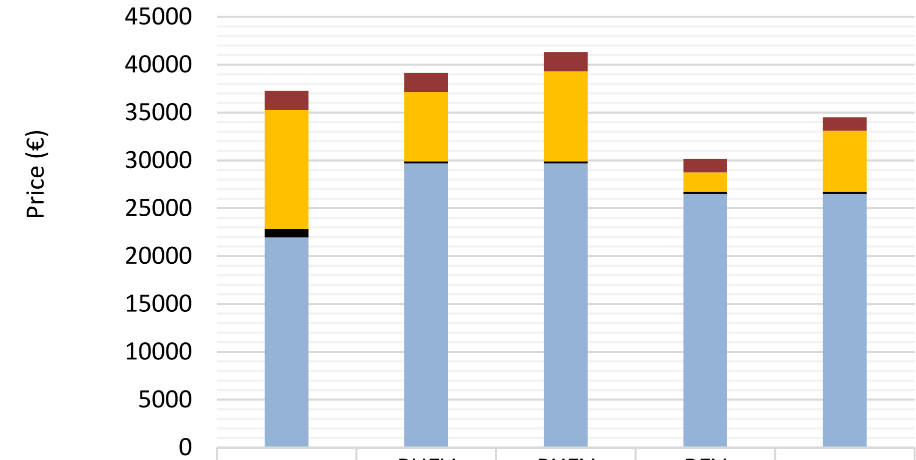
For the electric car (EV) charging at home we have assumed a 13 kWh/100, we will also consider that the EV owner is using Supervalle tariff. Using this assumption, the calculation is optimistic and can provide us the lowest price of electric charging vehicle. The price of the electricity in Supervalle time is 0,076 €/kWh. Spain has one of the highest prices of electricity in Europe (Ministry of energy, tourism and digital agenda in 2017)

About the maintenance cost according to the Renault Vehiculo Electrico (2017) article, the price of the maintenance cost for 200.000km electric vehicle is about 30% less than the Gasoline vehicle. The maintenance cost of a medium size Gasoline vehicle (Renault CLIO IV) without any reparation costs is 2000€, so, the maintenance cost of Electric vehicle is 1400€ (Renault ZOE).

Graphic 38 Show the comparison between the Gasoline vehicle, PHEV and EV. The purchase cost is the result of the Graphic 37.

Graphic 38. Comparison between the Gasoline vehicle, PHEV and EV purchase and usage costs.

Units: EUR



	Gasoline	PHEV (Home)	PHEV (FCS)	BEV (Home)	BEV (FCS)
Maintenance	2000	2000	2000	1400	1400
Usage costs (200,000km / 10 years)	12440	7230,8	9412	2021,6	6384
IVTM (10 years, Type 4)	866,1	216,525	216,525	216,525	216,525
Purchase cost	21950	29678	29678	26500	26500

Source: Own creation using data from Ministry of energy, tourism and digital agenda Web, 2018. Ministerio de Economía, Industria y Competitividad Web,2018. Renault. 2017. "Cámara de Comercio de España Comisión de Energía." *Tesla S* and own assumptions.

As we have already explained in Norway analysis, the prices that we visualize in the previous graphic are not the final prices of the owner of a EV. We must bear in mind, that these costs are pure costs of using the electric vehicle while EV, will also be able to take advantage of economic incentives such as, free toll roads, free parking and free charging. However, these expenses will depend greatly on the type of use made by the owner of the electric vehicle and are very changeable depending on the routes and areas where the EV is driven.

6.2.2.2 Direct subsidies to users reducing usage costs and range challenges

6.2.2.2.1 Free toll roads in week days (2015)

The electric cars since 2015 can circulate in a completely free way through the tolls of the highways managed by the "Generalitat de Cataluña". The approximate price of the toll road from Perpignan to Barcelona (200km) is 12€ per way. The measure aims to encourage the purchase and use of plug-in vehicles as an alternative to less polluting transport.

6.2.2.2.2 "Supervalle" electric fee (2012)

The tariff "Supervalle" established by the electricity companies of Spain consists of a reduced rate in night hours to take advantage of those hours to charge the battery of the electric vehicle and achieve to reduce up to 50 cents of expenditure per 100km.
The night recharge, in addition to lowering the costs of electricity "fuel" of the electric car help the electrical system to work better and to take advantage of the energy produced by facilities such as Wind Power, since normally in those hours the demand of consumers is lower.

With the "Supervalle" rate, during the hours of nocturnal charge, the kilowatt is much cheaper than usual, 0,140439 €/kWh in normal hours and 0,073738 €/kWh in "Supervalle" hours. Counting that you recharge the car during 5-8 hours, between 1 a.m and 7 a.m, you will be taking advantage of your sleep hours which are also the hours when the price per kilowatt is lower.

6.2.2.3 Reduction of time costs and giving relative advantages

6.2.2.3.1 Access to bus HOV (VAO) lanes (2015)

Electric cars have free access to the bus-HOV lane. That is to say, they will be able to circulate in this lane although they circulate with a single occupant. This was published by the DGT in the resolution of January 30, 2015, which establishes the special traffic regulation measures during this year. Therefore, electric cars can circulate with a single occupant in the central lane of vehicles with high occupancy (HOV). Vehicles with zero emissions classified according to the Vehicle Registry of the General Directorate of Traffic may use this lane as:

- Battery electric vehicle (EV).
- Extended range electric vehicle (EREV).
- Plug-in hybrid electric vehicle (PHEV) with a minimum autonomy of 40 kilometres.

To do this, the owners of these vehicles must request in the DGT this sticker that must be located on the front windshield so that the authorities can verify that their car is zero emissions.

Figure 11. Zero emissions sticker that allow vehicles use HOV lane.

Source: Dirección general de tráfico (DGT) Web, 2018.

6.2.2.3.2 Access to APR's (Residential priority Areas) (2015)

The Priority Areas of the Madrid City Council (APR) are spaces in which the access of vehicles to non-residents is restricted in order to preserve the sustainable use of the roads included in them, as well as to reduce the levels of acoustic and atmospheric contamination of said spaces. Since 2015 The cars that have the authorization Zero Emissions of the Parking Regulated Service are allowed to use these areas.

6.2.2.3.3 Free parking (2014)

Most of the parking places in the centre of Barcelona are “blue” or “green”, depending of the price per hour of the zones. Normally green parking has a higher price than blue one and are in the zones with most traffic of Barcelona. Since 2222 Zero Emissions cars can park free in blue or green zones using the Zero emissions sticker.

6.2.2.3.4 Free charging (2013)

As happened in Norway, in Spain EV owners can charge their vehicle in Supermarkets and commercial centres totally free. Ikea, El Corte Inglés, some shopping centres such as Carrefour and hotel chains had requested the Ministry of Energy permission to charge energy to users who charge their electric cars from the charging points they have installed in their shopping centres.

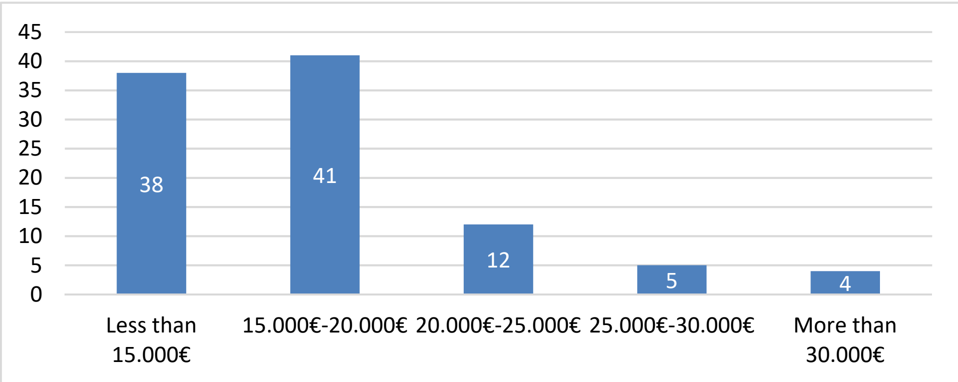
The problem is that according to the electric law passed in 2013, shopping centres cannot register as electric managers, something that prevents them from charging directly for energy in any way. Put another way, new shopping centres are required to have charging points for electric cars but cannot charge for their use. A charging point for an electric car is expensive and shopping centres do not see the return on investment directly or indirectly, however, it can be used to attract customers to the centre with the incentive to have EVSE available during the shopping.

6.3 Spanish population pros and cons of EV

As the analysis done in Norway and Japan, we will analyse in this part the EV opinion about different aspects of EV through a quantitative market study of 500 people of Spain with a technical methodology of computer-assisted web interview of simple random sample of people.

The results of the survey are shown in Graphics 39, 40, 41, 42 in function of the question.

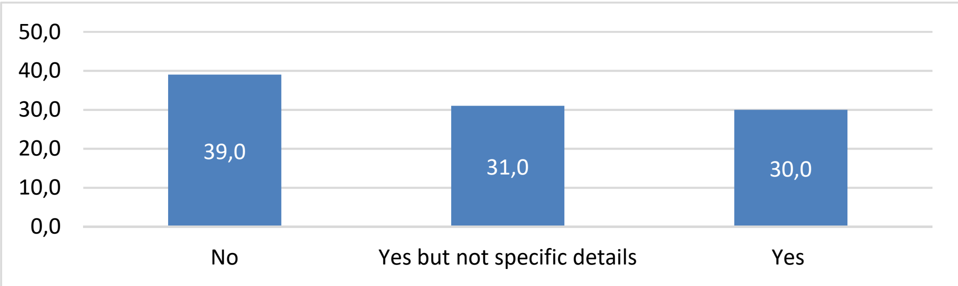
Graphic 39. How much would you be willing to pay for a new EV?
Units: Percentage (%) of total answers.



Data source: feebbo. (2016). Market study of Electric Vehicles in Spain, *"Estudio de mercado sobre vehículos eléctricos. 1–21"*

The result of the surveyed sample in Spain shows that 41% of population would pay from 15.000 to 20.000€ in the purchasing of an EV and 38% would pay less than 15.000€. As the comparison of purchase price of EV shows, the mid-size and mid-class EV purchase price reach the value of 26.500€, that means that reducing the total unit price of EV the possibility of a huge increase of market share is high.

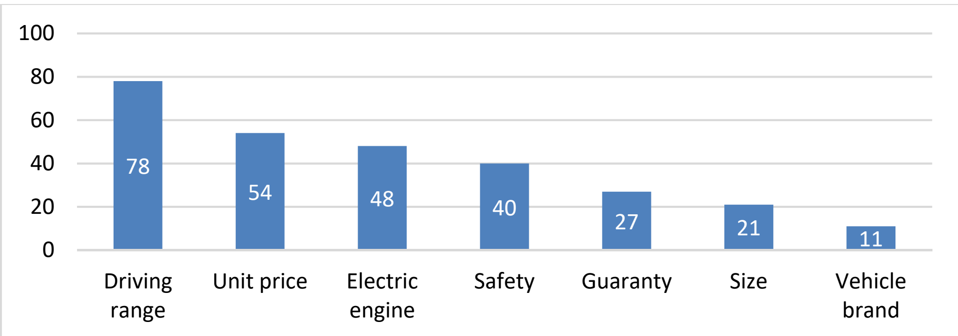
Graphic 40. Did you know about the EV subsidies?
Units: Percentage (%) of total answers.



Data source: feebbo. (2016).Market study of Electric Vehicles in Spain, *"Estudio de mercado sobre vehículos eléctricos. 1–21"*.

Graphic 40 shows that as important are the efforts to reduce the price of EV through fiscal incentives and subsidies as the popularisation and knowledge transferred to the population. The 38,6% of surveyed sample answer negatively the question about their knowledge about the EV fiscal incentives and subsidies. This fact, indicates the lack of promotional events about EV in Spain and the loose of possible future EV owners due to lack of information about them.

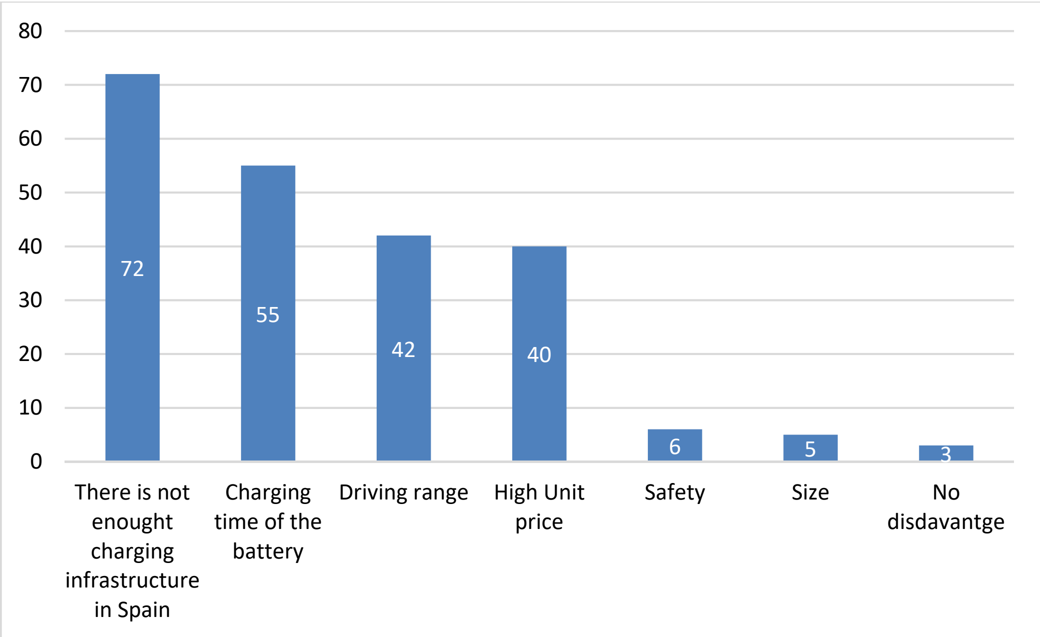
Graphic 41. What do you care about when considering purchasing EV? (More than option permitted)
Units: Percentage (%) of total answers.



Data source: feebbo. (2016).Market study of Electric Vehicles in Spain, *"Estudio de mercado sobre vehículos eléctricos. 1–21"*.

Graphic 41 shows which concerns about EV are more valued for Spanish population. First, the main concern of future EV owners is the driving range with a 28,1%. Following, the unit price is the second concern for future EV owners, this fact matches with the higher price of the EV regarding to Gasoline vehicle price. As we saw in Gasoline vehicle and Electric vehicle purchasing price comparison, EV purchase price with all fiscal incentives and subsidies is 18% higher than Gasoline vehicle purchase price. A highlight of the possible ignorance about fiscal incentives and subsidies could make the sample of the survey answer about a higher price of EV than the real one.

Graphic 42. What do you think EV as disadvantage? (More than option permitted)
Units: Percentage (%) of total answers.



Data source: feebbo. (2016).Market study of Electric Vehicles in Spain, *“Estudio de mercado sobre vehículos eléctricos. 1–21”.*

Graphic 42 shows the opinion about Spanish population of EV disadvantages, as is the same than which elements need to be improved to not figure out like disadvantages. The main element is the lack of charging infrastructure in Spain with a 72%, this value confirms that the actual rate of PEV per EVSE is not enough for Spanish population satisfaction of charging infrastructure. The second main disadvantage for Spanish population is the charging time of the battery with 55%, this element could be solved using fast charging stations, however, technology is increasing more and more and battery charging time will be lower and lower, so, this is a temporally problem with an increasing solution. Finally, in almost the same level of disadvantage, driving range with 42% and high unit price with 40% are the third and the fourth position disadvantages.

6.4 Spain conclusions

Now, Spain has an amount of plug-in electric vehicles (PEV) of 20,000 units. Unfortunately, this amount represents 0.1% of total passenger cars in Spain. However, as we have seen in Graph 32, the market share is undergoing strong growth, in detail, from the year 2015 representing 0.22% (0.08% EV, 0.14% PHEV) at year 2017 representing 0.61% (0.32% EV, 0.28% PHEV) tripling the market share of plug-in electric vehicles in Spain.

This growth is the result of the effort that the Spanish Government is carrying out in the establishment of incentive measures since 2004 to promote the electric vehicle among the population. These measures have a mixed character and are composed of fiscal incentives and subsidies for reduction of purchase price, direct subsidies to users, reducing usage costs and range challenges and reduction of time costs and giving relative advantages.

Regarding the investment that the Spanish Government is dedicating to the increase in the electric vehicle recharge infrastructure, it has been an amount of 22.5 million euros until 2018. The result of these Investments has been a network of electric charging stations composed of 4312 normal charging stations and 662 fast charging stations. However, the market study studied in this section shows that the main preoccupation or disadvantage of the Spanish population over the electric vehicle is the lack of electrical charging infrastructure spread throughout the country. Specifically, 72% of respondents mark this option as a disadvantage. On the other hand, the largest investment dedicated to the increase of infrastructure of electric charge for the Spanish Government (15 million euros) has been carried out in 2018. This fact shows the awareness and the pre-disposition of the increase of infrastructure of electric charge.

On the other hand, in relation to the subsidies that Spain is giving for the direct help of the purchase of the electric vehicle, although the amount of subsidized purchases per year cannot cover more than 5500 electric vehicles, the monetary amount of these subsidies seems to satisfy users who can enjoy them. According to the market study of this section, the price of the electric vehicle occupies the fourth place in the main disadvantages of the electric vehicle (Graph 42). However, 40% of people who have responded to the market survey thinks that the price of the electric vehicle in Spain is a disadvantage.

This is because the price of the electric vehicle with the tax incentives and the subsidies included is 17.7% higher than that of the Gasoline vehicle, which represents approximately € 4500 in the purchase price. On the other hand, if we analyse the price comparison, which includes the use costs for 10 years for the EV and the gasoline vehicle (graph 38), we see that the price of the EV is 8% cheaper, respectively. This factor indicates that the Spanish population needs to see a global vision of the investment and not be based only on the purchase price.

Regarding the lack of a global vision of the electric vehicle investment, it is important to note that there is a very important ignorance about the subsidies offered by the Spanish Government for the purchase of the electric vehicle. According to the market study of this section, 39% of the respondents expressed not knowing that the Spanish Government offers subsidies and 31% expressed having listened to talk, but not knowing details or amounts. It is important for the Spanish Government to disseminate socially the aid it offers to guarantee a satisfactory electric vehicle establishment.

7. Conclusions

7.1 Global Environmental Conclusions

Given the high GHG emissions and air pollutants that are emitting to the various layers of the atmosphere on our planet, we have seen that with the penetration of the new technology called electric vehicles these can be reduced very considerably. Of 23% of the total emissions of CO2 that represents the sector of the transport to the world, 73% is caused by vehicles of mechanical traction (heavy and duty vehicles) ("Global reduction in CO2 emissions from cars: to consumers perspective" 2015) and 53% falls on duty vehicles. Thus, in view of the utopia of 100% global electric vehicle development, CO2 reductions would be reduced by 17%, taking into account both types of vehicles to date, and a higher percentage taking into account the predictions of the increase in vehicles that are presented in the world at a global level. They would also reduce the diseases produced by pollutants (NOx, CO, NMVOC, PM, SOx) in cities that come from vehicles that circulate (Renault, 2017).

On the other hand, the development of the electric vehicle is initially taking place in countries belonging to the OECD, which correspond to the countries with a higher per capita GDP, the developed countries. However, OECDs already have a high awareness of the environment and with sustainable mobility today, those that do not have it are the Non-OECD where in the next 20-30 years according to the forecasts, the demand of, Urban private , non-urban road, and urban public, transport models will grow more than 50% (Outlook, 2017), all of them made up of mechanical traction vehicles that produce both CO2 and air-pollutants, and also emissions in this respect . Therefore, globally, it is counterproductive to introduce sustainable mobility in OECD countries to reduce emissions generated while in non-OECD countries these are doubling in the near future.

On the other hand, according to the graphs represented in the first section of this study (Graph 8) world oil consumption has not stopped growing in recent years and the time is not known in which humanity can use oil already which is not a renewable energy and is a limited resource. The transport sector is responsible for 54% of global oil consumption and, specifically, 45% of the petroleum derivatives are used for gasoline and E85 engines. Thus, the electric vehicle helps to reduce the dependence both global and local level in each country of oil. Another factor to take into account is the possible counterproductive effect of the possible destination of oil for the generation of electricity. This possibility has been ruled out based on graph 14 where it is seen that only 5% of the oil is destined for the generation of electricity worldwide and 20% of renewable energy is used for the generation of world electricity with a forecast in the reference case (EIA, 20171) from 10% to 20 years. There are countries like Norway, which nowadays generate 98% of electricity from renewable energy, unfortunately Spain generates 38.9% of electricity through renewable energies and Japan 15%.

7.2 Comparison Conclusions

Initially, the comparative aspects of immersion in new technologies are very subjective, since the boundary conditions of each one of the countries are different and, together with them, society, culture and motivations are also different and very difficult to analyze. So to carry out the comparative conclusions we will be based on the ENP market share that have reached Norway, Japan and Spain. Next, we will present the conclusions of the different factors that have led to each country at the current level and compare the opinions of the population based on the surveys.

Norway had at the end of 2017 a total market share of 39.19% between plug-in hybrid electric vehicles and electric vehicles while Japan has 1.6% and Spain less than 1%. This percentage is the result of the situation in each country regarding the adaptation of the electric vehicle as a new technology. The factors that intervene in the adaptation of the electric vehicle as a new mode of mobility are: charging infrastructure for electric vehicles, fiscal incentives and subsidies reduction of purchase price, direct subsidies to users and reducing usage costs and range challenges and reduction of time costs and giving relative advantages that are provided to users of the electric vehicle.

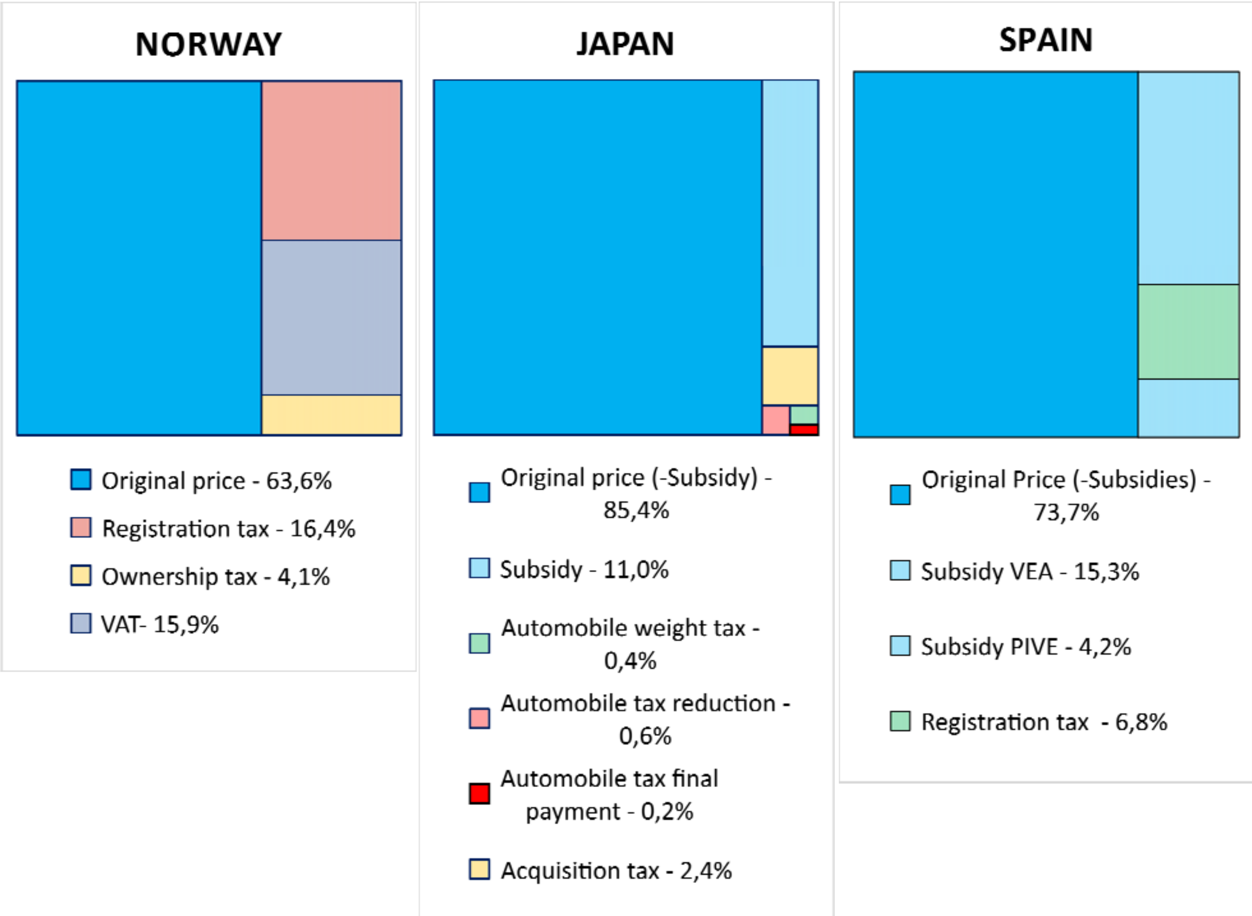
Regarding the investment of charging infrastructure of electric vehicles. Norwegian Government has invested 7.5 million euros, much lower amount in front of the 22.5 million euros of Spanish investment and 1000 million euros of Japanese investment. These amounts cannot be directly compared because of the different resources and GDP available of each country but it is important to highlight the explanation of the great results with low amount of money of Norway. According to the Norwegian Ministry of Transport and Communications in the National Transport Plan (2016), the total ban of gasoline and diesel, production, sales and new registrations in Norway since 2025. Norway will be the first world country to apply this measure, of private sector such as; Gas station companies, gasoline / diesel car companies or new investors, have been forced or have seen the opportunity to invest in business charging stations and the result of this fact is a net extended network of station charging.

On the other hand, Japan due to the public-private agreements with CHAdeMO association has achieved a number of fast charging stations throughout the country of 7100. Both normal and fast charging stations together represent 41,000 charging stations, which is higher than the total number of gas stations in Japan.

About the charging infrastructure, the different surveys made of each country, in all of them the opinion of the population, in Japan in second place with 60% of answers and in Spain in the first place with 70% of the answers, is that one of the biggest disadvantages of the electric vehicle is the lack of charging points in the country. This fact reflects that even with the immense investment in comparison with Spanish one, the charging infrastructure of Japan must be even greater to satisfy the need of the Japanese population to opt for the change to the electric vehicle.

In the case of the different incentives offered by each country, Norway, has made a difference between Japan and Spain since 1990, with the exemption of the registration tax, is providing incentives for the increase of the electric vehicle in the country. Japan began in 2001 with the acquisition tax reduction and Spain in 2004 with the reduction of the mechanical traction tax. This temporary difference between the beginning of the incentives to move the integration of electric vehicles could be one of the reasons why Norway has a great advantage in the market share of electric vehicles. On the other hand, Norway and Spain offer tax incentives and subsidies as regards the reduction of the sale price, direct subsidies to reduce the cost of use and the obstacles with the autonomy of the vehicle and incentives for the reduction of the user time cost and relative benefits. Japan, on the other hand, only offers tax incentives and subsidies in reducing the sale price. In the next sequence of graphics, we can see a summary of the reduction purchase price achieved by each country as a consequence of the incentives.

Graphic 43,44,45. Fiscal incentives and subsidies reduction of final price of EV comparison.



Source: Summary of graphic 20,27,39.

Fiscal incentives of Norway represent a reduction of 36,4% of the final EV price, Japan combination of fiscal incentives and subsidies represents a 12% (11% subsidies and 1% fiscal incentives) reduction of the final EV price, finally, Spain combination of fiscal incentives and subsidies represents a reduction of 26,3% of the total final price. As we see Norwegian reduction of the price is the highest. The economic strategy of having such high taxes on the purchase of a vehicle allows them to use only tax incentives the price is reduced for the most part and below the price of the gasoline vehicle (25% lower), however, the sustainability of these incentives by the Norwegian government should be a point to study since such high incentives represent a very high and often unsustainable loss of income.

In relation to Japan, the economic strategy in terms of collecting taxes through the purchase of a vehicle results in low taxes compared to the price of the vehicle, thus, the Japanese government must encourage the population to make the change to the electric vehicle through incentives. However, these incentives are not very high and do not get the price of the electric vehicle closer to that of the gasoline vehicle (39% higher).

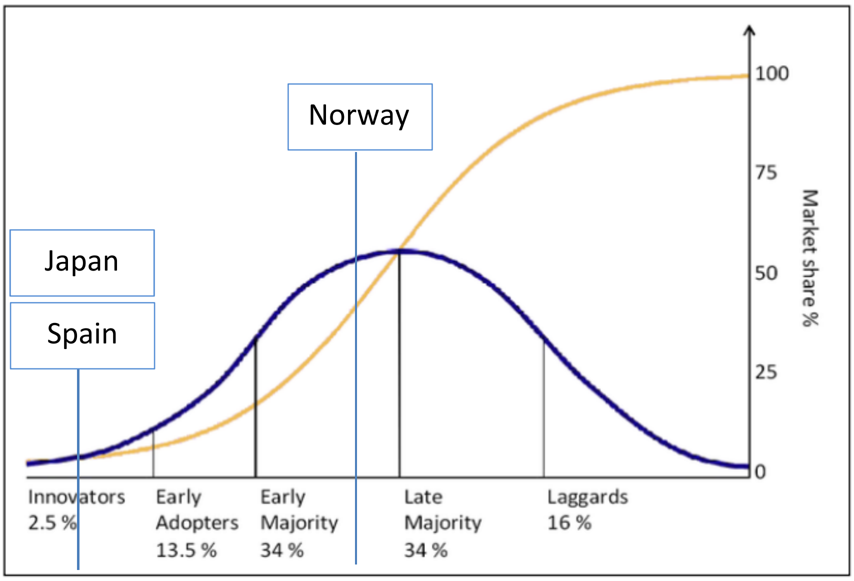
As a result of the purchase of electric vehicles and using the survey conducted in Japan as corroboration, the Japanese population that acquires an electric vehicle today is due to the charge of awareness and involvement in the personal environment, Japan is a country that has demonstrated to be very aware of the environment since 1990 when subsidies for hybrid non-plug-in vehicles began to be provided in order to start reducing emissions.

As for Spain, it has a mixed system between the Norwegian and the Japanese system, although with tax incentives it manages to reduce the price of the electric vehicle by 6.8%, the subsidies help make the difference by increasing the 15.3% price reduction. Spain also fails to reduce the price of the electric vehicle below the price level of the gasoline vehicle, currently the value of the EV is 17.7% higher.

It should be noted that in the case of comparing prices including the price of use of vehicles for 10 years or drive 200,000km, due to the higher price of gasoline compared to the price of electric recharging both in the case of recharging only at home or recharging only in fast charging stations, the lower maintenance cost of the EV and the incentives in annual rates in the case of Japan, the final prices of the EV and the gasoline vehicle both, in Japan and in Spain, are more balanced. In the case of Japan, the EV is still more expensive, but the distance is cut to 12.5%. In the case of Spain, the gasoline vehicle exceeds the EV price by 7.4%.

Finally, it is important to understand the behaviour of the adaptation curve of the new technologies among the population and where is Norway, Japan and Spain to be able to take positive actions for the growth of the market share of the EV. In the following image, we can appreciate the design of the adaptation curve named "Rogers' Adopter Categories" (Dube & Gumbo, 2017) mixed with our ubication of each country

Figure 12. Roger's Adopter Categories.



Source: Own ubication of countries in the curve using Dube, Cinderella, and Victor Gumbo. 2017. “Diffusion of Innovation and the Technology Adoption Curve: Where Are We? The Zimbabwean Experience.”

We have located Japan and Spain in the same area of the curve since both are in the first phase of development of the electric vehicle in terms of market share. Due to the large network of electric vehicle charging infrastructure that Japan has available it is possible that the growth of Japanese market share is faster than that of Spain but today both share the location within the adaptation curve of new technology as "innovators". According to (Dube & Gumbo, 2017) the stretch of the most difficult curve is the process of crossing the area of "early adopters". In this process is where the efforts of each of the countries to promote the electric vehicle will be reflected. Norway has a market share of electric vehicles taking into account the PHEV of approximately 40% if it is located in the "early majority" area of the curve since it is still a way to get 100% of electric vehicles, but without any doubt, it is going in the right direction to achieve it and it shows it with proposals such as the prohibition of petrol and diesel vehicles in 2025.

7.2 Spain further challenges

Initially, Spain has a 35% interest rate of electricity generation from renewable energies, in the face of the near future the Spanish government should take measures and work to increase this percentage to possible levels such as those of Norway for that purpose to reduce oil consumption, emissions, and also to create a sustainable mode of transport from electric vehicles.

As we have seen in the responses of the market study of the Spanish population, there is a huge lack of knowledge about the advantages of the Spanish government for the acquisition of an electric vehicle. There is a need to act face to face in this aspect and through the media or others to bring this information to the population. The entire population that does not know the incentives that the Spanish government dedicates to the increase of the market share in Spain is the people that will not think about an electric vehicle in the next purchase.

Given the consecutive ending year after year in the first 24 hours of the subsidies granted by Spain for the purchase of an electric vehicle, the Spanish government should make the reflection of investing a greater amount to subsidies because of the desire of the Spanish population to make the change of traditional vehicle to electric vehicle but as stated (Renault, 2017) the electric vehicle market is paralyzed year after year due to the lack of resources that the Spanish government destines to subsidies .

Car owners who use street parking on a daily life and don’t have access to charge at work, will continue as a challenge. The charging points in the streets are expensive and it is possible that new additional solutions are required. As we move towards a faster charging, this may seem like a promising solution to this challenge. However, the cost of end user for this type of charge remains uncertain. As new smart charging solutions, autonomous automobiles, car sharing and many other innovations are evolving at a rapid pace. It's relevant to have an open mind when designing new transportation and cargo solutions for our cities.

7.3 Further studies

Initially regarding the environment, a study of the measures taken by the OECD to stop the growth of demand for vehicles in non-OECD countries and possible measures to stop this growth is necessary to obtain a global vision of the electric vehicle.

About the electric vehicle charging infrastructure of Norway, Japan and Spain, a study is required that shows an approximation of the optimal value of normal and fast freight stations in each of the countries and the distribution according to urban areas and Interurban to be able to get an idea of whether the actual lack of freight stations is or could be a problem in the future development of electric vehicles in each country.

Regarding the incentives offered by each country, a study on the sustainability and possible sustainable expansion of these is necessary to know the durability of the incentives and if these could be increased without presenting a deficit in the government. Also, analyse the possibility of the adoption of new incentives between countries. A study on the possible reasons why the Spanish government is not investing more in the electric vehicle could be used to know how oil companies or companies engaged in the sale of gasoline or diesel vehicles pressures to curb the development of electric vehicles.

Finally, a general study of the impact and the measures that should be made in the new buildings in relation to the electrical network in order to know if a 100% fleet of electric vehicles could be held, and in case Negative, what reforms and measures should be taken to achieve this goal.

List of acronyms and definitions

GHG: Greenhouse gases.
PEV: Plug-in electric vehicle (EV + PHEV).
EV: Pure electric vehicle.
PHEV: Plug-in hybrid vehicle.
EREV: Extended-range electric vehicle.
ICE: Internal combustion engine.
EVSE: Electric vehicle supply equipment
OECD: Organisation for Economic Co-operation and Development (OECD)
NASA: National Oceanic and Atmospheric Administration data.
CO_2: Carbone dioxide.
CO: Carbone monoxide.
NOx: Nitrogen oxides.
PMø10: Particulate matter 10µm diameter.
PMø25: Particulate matter 25 µm diameter.
NMVOC: volatile organic compounds.
Sox: Sulphur oxides.
LPG: Liquefied petroleum gas.
EUR: Euro
NOK: Norwegian krone
JPY: Japanese Yen.
VAT: Value added tax.
METI: Ministry of Economy, Trade and Industry of Japan.
MOVEA: Movilidad con Vehículos de Energías Alternativas
MOVALT: Movilidad con Vehículos de Energías Alternativas
VEA: Vehículos de energías alternativas
PIVE: Programa de incentivos al vehículo eficiente.
IVTM: Impuesto sobre vehículo de tracción mecánica.
IRPF: Impuesto sobre la renta de personas físicas.
APR: Residential priority Areas.

List of OECD countries: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Referent case: The Reference case assumes continual improvement in known technologies based on current trends and relies on the views of leading economic forecasters and demographers related to economic and demographic trends for 16 world regions based on OECD membership status.The IEO2017 considers current policies, as reflected in current laws, regulations, and stated targets that are judged to reflect an actual policy commitment—for major countries with the goal of realistically capturing their effects in the projections. Projections in the IEO should be interpreted with a clear understanding of the assumptions that inform them (e.g., economic growth, population, world oil prices, and existing government regulations and policies) and the limitations inherent in any modelling effort.

Baseline case: scenario. It takes account of broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-energy subsidies, even if the measures to implement these commitments have yet to be identified or announced.

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